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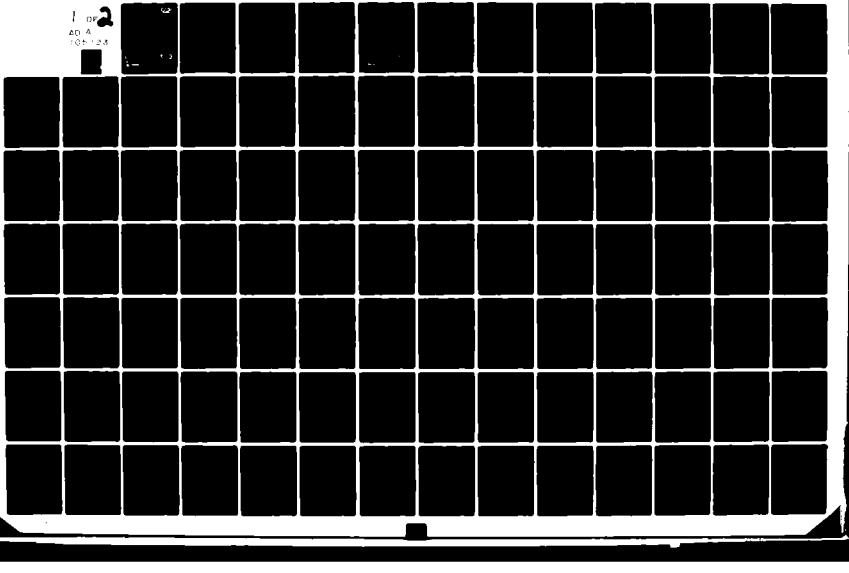

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(6) COLLABORATIVE DEVELOPMENT OF MAIN BATTLE TANKS: LESSONS FROM THE U.S.-GERMAN EXPERIENCE, 1963-1978

(10) Thomas L. McNaugher

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Examines the U.S.-West German effort to collaborate in the development of main battle tanks. The effort began in 1963 with the MBT-70 program, an ambitious cooperative attempt to develop a single tank. Because the two armies could not reconcile their differing concepts of tanks and tank warfare, this effort produced a complex and expensive tank and increasing duplicative development work in each nation. In 1969 the program was aboandoned, and each nation set about developing its own tank. Collaboration was suggested again in 1973, this time as an effort either to sell West Germany's Leopard II to the U.S. Army or to trade components across ongoing national development programs. The latter effort produced an agreement to mount the German 120mm gun on later versions of the U.S. XM-1 tank, but this amount of collaboration succeeded only after substantial political debate in the Congress. The note discusses major impediments to collaboration in these cases, and suggests strategies for future collaboration on armored vehicles. 93 pp. (Author)

A RAND NOTE

COLLABORATIVE DEVELOPMENT OF MAIN BATTLE TANKS: LESSONS FROM THE U.S.-GERMAN EXPERIENCE, 1963-1978

Thomas L. McNaugher

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PREFACE

In agreeing on its Long-Term Defense Program in 1977, NATO recognized the importance of rationalizing its defense posture. Since then the NATO member states have pursued a variety of efforts to improve Alliance cooperation. Among these has been a concerted drive to standardize weapon systems, components, and consumables like fuel and ammunition, with the goal of achieving more efficient use of production facilities among NATO members and improving the operational compatibility of military equipment in wartime. Collaboration among members in the development of new weapon systems has thus become an important component of NATO's current improvement program.

Collaboration is defined here broadly to include any attempt to coordinate the development of new systems in an effort to rationalize defense production or to achieve standardization or interoperability of military equipment. At one extreme, it may involve a nation forgoing development of its own equipment in favor of buying a particular system from an ally. At the other extreme, it may involve multinational cooperation in the development of a single new system or set of subsystems. Between these extremes lie efforts to trade subsystems across national boundaries.

The United States has acquired limited and largely one-sided experience in these areas. It has sold systems like the M-48 tank or the TOW anti-tank missile system to its European allies. It also has sold its allies the reproduction rights to systems like the F-104 fighter-bomber and the M-113 armored personnel carrier. But rarely has it reversed the direction of these processes, buying systems from Europe or joining with its allies in cooperatively developing a single system.

Concerning one weapon system and one ally, however, these generalizations do not apply: For nearly twenty years the United States and the Federal Republic of Germany (FRG) have attempted in a variety of ways to collaborate in the development of main battle tanks. Initial contacts made in 1961 soon blossomed into the MBT-70 program,

an ambitious attempt to develop jointly a single tank. When rising costs and unsolved technical problems brought this effort to a conclusion in 1970, each nation took up the development of its own tank, only to reopen the question of collaboration in 1973. Efforts begun in that year have borne some success, most notably the U.S. Army's decision to mount the FRG's 120mm smoothbore tank gun on future versions of its new XM-1.

Successful or not, these efforts have produced some twenty years of experience in a variety of ways of collaborating across national boundaries. This Note examines that experience in search of lessons for U.S. policymakers, who now are attempting to collaborate with their European allies over a broad range of weapon systems. It should be of interest to members of the acquisition policy community in the Office of the Secretary of Defense as well as in the Services themselves, especially the U.S. Army.

Initial support for the research documented here was provided by the Office of the Under Secretary of Defense for Research and Engineering. Preparation of this Note was supported by The Rand Corporation from its own funds. The views expressed are the author's, not necessarily those of the Department of Defense.

SUMMARY

For nearly twenty years the United States and the Federal Republic of Germany have tried in various ways to collaborate in the development of their main battle tanks. Out of initial contacts made in 1961 came a 1963 agreement to develop jointly a new and relatively sophisticated tank, the MBT-70. Although prototypes of this tank appeared in 1967, rising costs and schedule slippage already had made the program unpopular on both sides of the Atlantic, and in 1970 it was cancelled. Thereafter West Germany took up the development of its Leopard II, while the United States, after a brief and unsuccessful effort to modify the MBT-70 into the XM-803, began work on the XM-1. Efforts to collaborate across these national development programs picked up in 1973, and in 1974 the two nations agreed that the FRG's Leopard II would be tested in the United States for possible purchase by the U.S. Army or, barring that, that some effort would be made to "harmonize" the Leopard II and the XM-1 by exchanging components like guns, engines and fire control systems. This last effort produced a measure of success, notably the U.S. Army's decision to mount West Germany's 120mm smoothbore gun on its XM-1 as soon as the gun is fully developed.

Successful or not, these collaborative efforts comprise a major portion of the United States' experience in collaboration with one of its European allies in the design and development of a major weapon system. This Note examines this experience in an effort to distill from it lessons for policymakers interested in collaborating on a wider scale in the future.

THE MBT-70 PROGRAM

The unsuccessful MBT-70 program illustrates problems that can befall an attempt to work jointly on a new system from the "ground up," that is, from the negotiation of a mutually acceptable set of performance requirements through the system's design and actual construction. The program's U.S. and German managers, who agreed to share control of the project, were never able to enforce effective compromises during

the joint requirements process or the prototype construction phase of the program.

The joint requirements process, which began in 1963 and extended through 1965, faced problems in trying to integrate the competing demands of each nation's military service. Neither Army was willing to sacrifice what it saw as critical tank performance requirements. Because U.S. and German tank doctrines called for fundamentally different kinds of tank combat, these critical requirements also tended to differ. Likewise, each nation's representatives to the project sought to include in the written requirement favored components already under development on a national basis. Despite the use of a computer simulation to inform the requirements process, there occurred less a series of informed tradeoffs and compromises than the simple addition of seemingly conflicting national demands.

This added an element of complexity to the MBT-70 requirement which in turn created problems during the tank's actual development. The MBT-70's main armament provides a good example. The U.S. Army wanted its anti-tank missile, the Shillelagh system, on the tank, while the Germans preferred a more traditional tank gun. During the joint requirements process, the United States agreed to modify its Shillelagh system to fire a conventional projectile as well as a missile. The modification process, however, proved extremely difficult, time consuming and expensive. As these problems became apparent, the Bundeswehr began to develop its own 120mm tank gun as an alternative to the Shillelagh/gun system.

Duplication of development like that which marked the MBT-70's gun system marked the development of its engine and suspension as well. As development progressed and technical problems began to appear in some of the tank's primary components, still more duplication occurred. By the time the first MBT-70 prototypes appeared in 1967, hopes of getting one standard tank from the project had dimmed, as each nation added, or seemed likely to add in the future, components of its own design to the tank.

By 1967 duplication of effort plus continuing work on the MBT-70's technical problems had produced significant schedule slippage and cost

increases that made the project unpopular on both sides of the Atlantic. Unhappy with some of the tank's characteristics, not to mention its rising cost, the FRG reduced its participation in the joint project significantly in 1969. In the United States, Congressional criticism of the program led to a decision early in 1970 to terminate codevelopment entirely and proceed instead with national development of an austere version of the MBT-70 called the XM-803. When Army estimates placed the XM-803's cost at $850,000 to $1 million, the Congress cancelled this program as well. It approved instead initial funding for the development of an entirely new tank, the XM-1.

The MBT-70 program highlights the importance of seeing the requirements process as extending past the articulation of a set of written performance goals. If technology cannot be made to yield required performance at reasonable cost, initial goals must be compromised, new and less demanding requirements set. Although not all of the MBT-70's problems may be traced to the program's collaborative nature, collaboration added a degree of difficulty all along this extended requirements process. The attempt to mix each army's tank concepts and preferred components added complexity to the joint requirement for the MBT-70. As work on components began, the fact that these requirements had become the basis for a delicate balance of national, industrial and military interests in both countries made it difficult to renegotiate requirements as it became clear that the original requirements could not be met at reasonable cost. Duplication in development became a way of escaping compromise. Given that much is at stake in a major development project from a military, industrial and political point of view, these problems might be expected in other efforts to develop a major system jointly from the "ground up."

U.S.-GERMAN COLLABORATION SINCE 1970

After 1971, U.S.-West German collaboration in the development of their main battle tanks took a more modest form than that which characterized the MBT-70 program. The two nations did not take up the issue of collaboration until 1973, after each country had initiated its own tank development program. In a Memorandum of Understanding

(MOU) signed in 1974 they agreed that the U.S. Army would test the Bundeswehr's Leopard II for possible purchase, and that, barring success in that effort, they would try to achieve standardization of the XM-1 and the Leopard II by means of exchanging components between the two tanks. The first part of this agreement fell by the wayside late in 1976, when the U.S. Army tested the Leopard but did not adopt it. By 1978, however, the latter part of the agreement had produced a decision in the United States to mount the FRG's 120mm smoothbore gun on later versions of the XM-1.

That decision emerged only after its wisdom had been subject to considerable political debate in the United States. Indeed, if the chief problem besetting collaboration before 1971 arose out of the international U.S.-German relationship, after 1971 the chief impediment to collaboration arose out of the domestic U.S. political arena. The component exchange was opposed by members of the Congress who feared that this new form of collaboration once again might delay the U.S. Army's attempt to field a new tank. These Congressmen had played a principal role in cancelling the MBT-70 and XM-803 programs, and in appropriating funds for the XM-1's development had provided the U.S. Army with a set of guidelines for structuring that program. They made it clear that the service was to keep the tank's unit cost under control, its development on schedule. In short, they were especially interested in seeing this tank fielded on time and at reasonable cost.

By the time U.S. and West German officials reopened the question of collaboration in 1973, the XM-1 program, structured with Congressional guidelines in mind, was already under way. In order to control the tank's cost and schedule, the service had tried first to control the risk inherent in its performance requirement. It also planned a competitive advanced development phase for the program, which began in June 1973 with the award of contracts to GM and Chrysler for competitve development of XM-1 prototypes. It managed the program using design-to-cost techniques that promised to hold the XM-1's unit cost below a predetermined goal. Significantly, both contractors planned to employ the U.S. Army's standard 105mm gun in their prototypes on cost-effectiveness grounds.

Initially, collaboration and the XM-1 program ran in separate tracks. West Germany agreed to modify its Leopard II to fit U.S. Army requirements and to ship it to the United States for testing just after the Army planned to test its XM-1 prototypes. The XM-1's schedule went unchanged. The component exchange portion of the 1974 MOU, on the other hand, contained nothing specific, and hence offered no interference to the ongoing XM-1 development.

The two tracks collided in 1976, however, when U.S. and West German negotiators produced an addendum to the 1974 MOU whose major thrust was to commit the U.S. Army to purchasing the Bundeswehr's 120mm gun for the XM-1, while the Bundeswehr agreed to test and possibly purchase a U.S. turbine engine for its Leopard II. The addendum was negotiated shortly before the Army planned to announce the winner of the XM-1 competitive development program. Because the addendum made it necessary to modify both XM-1 designs for the engine and gun transfer, however, the Secretary of Defense delayed source-selection for up to 120 days to allow the redesign to occur in a competitive environment. After nearly three years of development, the XM-1 program had been delayed.

This was the first delay in the XM-1's development schedule and it almost immediately met with opposition in the Congress, especially from within the House Armed Services Committee. There the decision to mount the 120mm gun on the XM-1 was criticized for threatening the XM-1's cost and development schedule, and for potentially reducing the tank's combat effectiveness. In September 1976 the Congress passed the "Hillis Resolution," effectively delaying implementation of the component exchange for a year, and bringing the collaborative process under closer Congressional supervision. With Chrysler finally named the winner of the XM-1 competition in November 1976, the XM-1 program returned to a track separate from U.S.-West German collaborative efforts.

In January 1978 the Secretary of the Army confirmed the service's choice of the FRG's 120mm tank gun for the XM-1. He stated that the gun would be mounted on XM-1s after it had been fully tested and prepared for production in the United States. In the meantime,

XM-1 development and initial production would continue unimpeded, with the 105mm gun being the principal armament until the German gun had been readied. Because it left the XM-1 program unimpeded, this decision met with less opposition from the Congress. Indeed, after 1978 Congressional attention turned from collaboration with the FRG to perceived problems in the XM-1 prototype's turbine engine.

The XM-1 case highlights the extent to which collaboration can become a domestic political issue. This should not be surprising: unilateral development of major weapon systems involves a complex interaction of political and industrial actors, and collaboration usually can be expected to complicate things still further. Thus, political debate and compromise are likely to surround collaboration in areas besides that involving main battle tanks. This suggests a cautious approach to collaboration that differs starkly from that counselled by those who attach to collaboration great military and economic benefit. If collaboration is pursued purely for its perceived benefits, after all, *more* is better. If it is seen as a matter of potential political debate and compromise, on the other hand, *less* may be better. Political capital is a limited resource. It thus must be used sparingly and wisely if collaboration is to be realized at all.

CONCLUSION

It is not clear from the experience surveyed here that collaboration has produced the benefits often attached to it. The cost of collaboration cannot be cited with precision when the cost of *not* collaborating is unavailable for comparison. Nonetheless, it is difficult to pinpoint any way in which collaboration in the development of main battle tanks has saved money or time. Indeed, though precise numbers may be impossible to generate, it seems more plausible to argue that collaboration has cost both time and money. With the 120mm gun purchase the United States seems to be spending money, not saving it, in order to buy the presumed military benefits of interoperability and the political benefits of a "two-way street" between the United States and its NATO allies.

While there is no single answer to the question "what had made collaboration so difficult?", in the experience surveyed here the immutability of military requirements for new systems looms as a paramount impediment to collaboration. Requirements reflect an army's doctrine, and through doctrine they are tied to the other systems in an army's inventory; changing requirements on a major system like the tank may force changes in other systems expected to fight alongside the tank in combat. Requirements also tend to be the outcome of a fairly intense organizational process within a single military service, a process in which competing views of combat needs are weighed and balanced. Finally, requirements for new systems often have attached to them high emotional content; they represent systems in which servicemen are expected to risk their lives. For all these reasons, military requirements for a new weapon system cannot be changed easily once they are established. Yet change is often precisely what collaboration calls for.

Here again, this survey suggests a cautious approach to collaboration. In the realm of main battle tanks, component exchanges seem more likely to produce success than ambitious joint developments like the MBT-70 program. They are less likely to disturb established requirements, and in this case at least they proved to be more manageable politically. Significantly, component exchanges can produce significant amounts of interoperability in areas like ammunition and fuel, both of which are major battlefield consumables. That component exchanges are relatively conservative does not necessarily make them less worth having.

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FIGURES AND TABLES

I. INTRODUCTION

For the better part of the past twenty years, the United States and the Federal Republic of Germany (FRG) have tried in various ways to collaborate in the development of their main battle tanks. Robert McNamara first raised with the German Minister of Defense the possibility of such collaboration soon after he became Secretary of Defense in 1961. By 1962 McNamara's activities had produced a U.S.-German agreement to develop tank components cooperatively, and in 1963 the two nations agreed to develop jointly an entirely new tank, the MBT-70, for both armies. Prototypes of the MBT-70 appeared in 1967, but by that time the program had begun to suffer cost growth and schedule slippage that made it an increasingly unpopular enterprise in both nations. In 1970 the U.S. and the FRG thus cancelled further joint activities and embarked on purely national tank development projects.

Efforts to collaborate on tank development did not pick up again until 1973. In the meantime, the Bundeswehr (German armed forces), prototyped a much modified version of the MBT-70 called the Leopard II and planned for the new tank's production. Although the U.S. Army initially took much the same course, trying to shape the remnants of its MBT-70 design into a less complicated and less expensive tank called the XM-803, the Congress cancelled this project late in 1971. Thereafter, the service began work on an entirely new tank, the XM-1.

Beginning in 1973 the U.S. and German Defense Ministers took up the possibility of collaborating on this new generation of main battle tanks. In 1974 the U.S. agreed to test the Leopard II against its XM-1 prototypes and to buy the German tank if it proved better able to meet the U.S. Army's tank requirement. The two nations also agreed that should the U.S. army prefer one of its XM-1 prototypes over the Leopard they nonetheless should make some effort to "harmonize" their tanks through an exchange of components like guns, engines, and fire control systems. This latter form of collaboration has been successful; most notably, the U.S. Army has agreed to mount the Leopard's 120mm smoothbore gun on its XM-1 as soon as the gun is fully developed.

Successful or not, these collaborative efforts, taken in sum, comprise a major portion of the United States' experience in collaboration with one of its European allies in the design and development of a major weapon system. This Note examines this experience in an effort to distill from it lessons for policymakers interested in collaborating on a wider scale in the future.

The Note is divided into two major sections, one covering the MBT-70 project, the other focusing on U.S.-German collaboration since 1973. Each section teaches its own lessons. The lessons of the MBT-70 project stem from the problems U.S. and German participants in that program encountered in trying to formulate jointly acceptable tank requirements to guide the development of a single tank; the project's history outlines the vicissitudes of such a joint requirement process. Collaboration since 1973 has been of an entirely different kind. It also has involved new actors. In particular, the U.S. Congress, which stayed in the background during much of the MBT-70's development, was much more active in shaping the XM-1 development program and the collaborative process surrounding it. This portion of the Note thus focuses largely on the way in which domestic politics have constrained collaboration with the FRG.

To a great extent each section is self contained. Each has its own set of conclusions, its own lessons. Nonetheless, in a short concluding section the report takes a broad view of the entire twenty year period under examination here, and offers conclusions about the prospects for further collaboration in the tank area, as well as suggestions for how the chances for successful collaboration may be increased.

II. THE MBT-70: FORGING THE COMMON REQUIREMENT

The MBT-70 prototypes that first appeared in mid-1967 emerged from a process that moved from conceptualization of the tank's basic characteristics through the elaboration of a specific set of tank performance requirements to the design and construction of prototypes. Serious discussions of each nation's tank concepts began in 1961 as a result of initial discussion between Robert McNamara and the German Defense Minister, Franz Josef Strauss. By 1962 the two nations had generated a mutually acceptable set of tank characteristics that, with some modification, was approved by the NATO working group on main battle tanks in January 1963. It was on this set of characteristics that McNamara and the new German Defense Minister, Kai Uwe von Hassell, based their August 1963 agreement to begin jointly developing a tank, the MBT-70. In September of that year each nation's program manager appointed representatives to a working group that produced a more specific joint tank requirement, a task formally completed in March 1965. Thereafter German and U.S. firms began the process of designing and building the prototypes.

Despite the existence of ostensible agreement at each of its stages, by 1970 the MBT-70 program had dissolved as a joint effort, not least because the two nations disagreed over the tank's required characteristics. Beneath the formal structure of the MBT-70's development there thus seems to have been a requirements process that never really ended. In offering a brief history of the MBT-70 program, this section seeks to outline the special characteristics of the joint requirements process that contributed to the program's dissolution.

REACHING AGREEMENT: THE COMPROMISE OF 1963

That McNamara and his German counterpart signed an agreement to launch a joint program by no means signalled the existence in Germany and the United States of compatible interests in and goals for the MBT-70 program. Rather, the August 1963 agreement emerged from a negotiating process to which each party brought its own interests

and goals, and in which each compromised in order to get the program started. In particular, the agreement papered over a basic difference in the sense of urgency with which each army approached the new project. Although the issue may have been somewhat ambiguous in 1963, even then it seemed clear that the Bundeswehr needed the new tank far less urgently than the U.S. Army.

When McNamara took office early in 1961 he found the U.S. Army deeply involved in work on a new tank to follow its M-60. Although it had been standardized only two years before, the M-60 represented little more than an update of the Army's M-48, whose parentage went back to 1945.[1*] Thus the service was pursuing the new development with some urgency. In 1957 the Army's tank community had produced a requirement for the new tank, and though this requirement was not formally endorsed by the Department of the Army until 1959, it immediately became the basis for the development of components for the new vehicle. The Army wanted a system much improved over the M-60, and hence some of these components were new and fairly sophisticated, including an automatic loader to replace one tank crew member, a stabilized turret to permit aiming and firing on the move, and the Shillelagh anti-tank missile system that had been under development in a separate program since 1957. The Army hoped to field the new system around 1965.[2]

By contrast, although the FRG had only begun to rearm in 1956, by 1961 it already was on the verge of producing a new tank. This weapon was the product of a multi-national project, one begun in 1957 with France. Conceptual differences finally sent each partner on its own way in 1959, France to the completion of its AMX-30, and the FRG to further development work on what became the Leopard I. When McNamara first broached the subject of a joint tank development program to Defense Minister Strauss in 1961 the Leopard I was already available in prototype form, and the Defense Ministry had already decided to produce a new system. Thus Strauss showed little interest in McNamara's idea. Indeed, he suggested that if the U.S. Army wanted a new tank, it should buy the Leopard I.[3]

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*Footnotes begin on p. 76.

For the time being, the two defense ministers agreed only to a joint tank component development program, although McNamara hoped that even this might "lead to mutual development of an end item . . . acceptable to both Armies. . . ."[4] This arrangement satisfied the FRG's desire to acquire information about new technologies from the U.S. tank R&D program, while it did not commit the Germans to developing a system they did not need. And it also satisfied the U.S. Army, in part because it in no way disrupted the Army's ongoing tank development program, and in part because the Army's tank experts generally considered the development of tank components the proper way to begin the development of a new tank.[5]

The arrangement did not satisfy McNamara, however, and the Defense Secretary continued to push for collaboration in the development of a single tank. McNamara stated his reasons for so doing in 1965:

> I am interested in . . . [the MBT-70] project because I am convinced that joint development efforts of this sort with our NATO allies . . . can be highly beneficial to all concerned. The pooling of ideas and sharing of costs should make for a better end product at lower expense. Identical items of equipment in our inventories simplify maintenance and support problems and exemplify that cooperation which is essential to NATO's success.[6]

Several participants in the program noted an additional reason in the need to rectify a serious U.S. balance of payments problem that had emerged late in the previous decade.[7]

By 1963 McNamara's persistent efforts to interest the FRG in a joint program finally produced results. Through the aegis of the component development program as well as discussions between tank experts from each nation, Germany and the U.S. formally agreed upon a general set of desirable tank characteristics in 1962. As soon as these had been accepted by the NATO working group on main battle tanks, McNamara and the new German Defense Minister reached tentative agreement on the outlines of a joint program. Formal agreement on the program came on 1 August 1963 in a letter of agreement signed by both defense officials.

The agreement treated only vaguely the key issues of what kind of a tank would be built and what organizational arrangements would be needed to handle the process. It defined broad guidelines for the tank's development, specifying that the MBT-70 would

> offer improvements in firepower, mobility, and protection over the M-60A1, . . . be capable of operating on a battlefield where tactical nuclear weapons are employed, . . . be armed with a tube-fire missile, or both a missile and a gun combination, and . . . have the latest electronics for communications, navigation and fire control.[8]

As the first U.S. program manager later noted, however, these guidelines "were not at the level of detail that one would normally associate with a Qualitative Materiél Requirement (QMR)," [9] the statement of specific requirements used by the U.S. Army as a basis for its development projects. Likewise, although the agreement created a "Program Management Board (PMB)" on which a German and an American representative would share power, it left further managerial and organizational arrangements unspecified.

On cost and scheduling issues the agreement was more specific. It cited a development cost estimate for the MBT-70 of $80 to $100 million. And it committed the two participating nations to sharing costs up to the $100 million limit on a 50-50 basis. Finally, the agreement set a firm production deadline of December 1969.

The agreement committed the FRG to working on two tanks at once--its own Leopard I, which in 1963 was being prepared for production, and the MBT-70. It may be that Germany gave up the joint component development effort in favor of a major tank development project in order to gain the technology spinoff a large project like the MBT-70 promised to give. It had been German policy since 1956 to engage in collaborative weapons projects in part to nourish its military research, development and production capabilities.[11] It also may be that in signing the agreement Germany was seeking simply to accommodate an important ally.[12] Whatever the FRG's reasons for agreeing to the MBT-70 program, it seems unlikely that it entered the project with the same sense of urgency felt by the U.S. Army.

Indeed, on this point the August 1963 agreement involved a fundamental compromise that would raise real problems as the project moved forward. The agreement pushed the U.S. Army's desired acceptance date for a new tank back four years from 1965 to 1969. The service accepted this condition only because the agreement contained a withdrawal clause that allowed either partner to quit the project on two-months' notice.[13] But while the U.S. Army thus had a strongly felt need for the new system, the Bundeswehr felt no similar need. If its Leopard problem worked out well, it would not need a new tank until well into the 1970s.

GETTING STARTED

The U.S. program manager, Major General Welborn G. Dolvin, and his German counterpart, Dr. Fritz Engelmann, first met in September 1963. They turned immediately to the two tasks that had to be accomplished before actual construction of the MBT-70 could begin; organizing and staffing their project, on the one hand, and refining a requirement sufficiently precise to allow for the new vehicle's design and construction, on the other. They completed these two tasks more-or-less simultaneously over the next year and a half.

They began by creating four working groups to examine major areas of concern to the project. One working group looked at tank concepts, one at military requirements, while another handled problems of specifications and standards, and the fourth looked into legal and funding problems.[14] Each working group enjoyed equal participation from the U.S. and the FRG. Of the four, the Military Requirements Working Group handled the crucial task of taking the operational characteristics outlined in the August agreement and turning them into a precise requirement for the MBT-70.

Dolvin and Engelmann both realized that, lacking a single executive, the requirements formulation process might bog down in debates over differing national tank concepts.[15] To prevent this, the two decided to contract for an "impartial" parametric design and cost effectiveness PD/CE study. They awarded the contract for the study to Lockheed Sunnyvale in December 1964. Taking the operational

characteristics of various tank components then available in the U.S. and the FRG, Lockheed hoped to create in its computers a "rubber tank"--one whose characteristics could be altered at will by the computer programmers. By running each tank through simulated combat, the study promised to produce a single most cost-effective tank design. Dolvin saw the study as "an impartial referee," that would "settle disputes between national interests."[16] With the Military Requirements Working Group and Lockheed Sunnyvale attending to the study, Dolvin and Engelmann turned to the problem of organizing and staffing the project.

Organizing for the MBT-70 Project

In his memoirs of this period, Dolvin relates that he and Engelmann had free rein to organize the MBT-70 project as they pleased. They could have run the program as a multinational corporation, for example, although they decided that legal complexities alone made such an arrangement impractical.[17] Instead, in March 1964 the two program managers settled on what amounted to a set of parallel hierarchies that shared power just as they did.

Each hierarchy contained two levels (see Figure 1). To implement technical alternatives and decisions, Dolvin and Engelmann created the Joint Engineering Agency (JEA), on which would sit government and military experts from each nation. For the U.S. side of the JEA, Dolvin began gathering representatives from the Army's Tank Automotive Command plus the other technical commands involved in tank development. Because the Bundeswehr had no technical commands of its own,[18] Engelmann staffed his side of the JEA with experts from the Defense Ministry's Federal Defense Equipment and Procurement Office.

Beneath the JEA sat the Joint Design Team (JDT), to be staffed by representatives from contract firms in each nation who would be charged with actual design work. Lacking any single contractor able to handle a development of this size, the Federal Republic put together a consortium of firms especially for the MBT-70 project. This "German Development Corporation," which included Krauss-Maffei, Daimler-Benz, Porsche and Rheinmetall, represented Germany on the JDT.

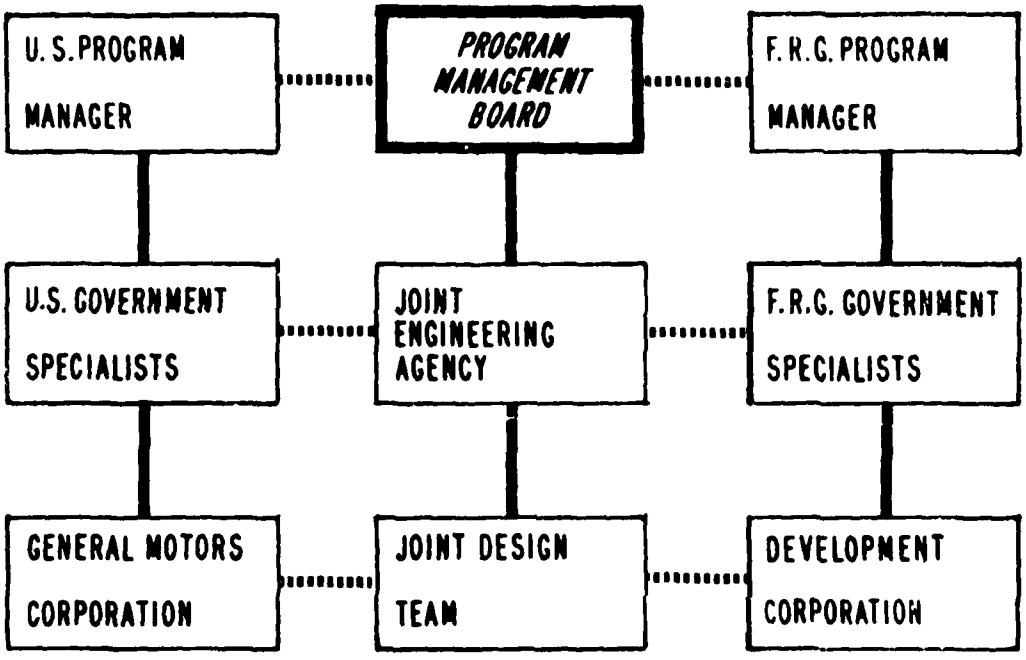

Fig. 1--MBT-70 Management Organization

SOURCE: Dolvin, *Lessons Learned*, p. 42.

Faced early on by this consortium, Dolvin ran an expedited competition on his side of the Atlantic, and in July of 1964 General Motors became prime contractor for the U.S. side of the joint project.[19] This firm then sent its people to man the U.S. side of the JDT.

Over their own national teams, Dolvin and Engelmann exercised unitary authority. Still, the two program managers shared authority over the joint program, and the arrangements they established made it inevitable that all decisions would be negotiated, and that tough issues would rise to the top for resolution. The effects of these arrangements can be seen in some of the program's earliest decisions. Having constructed an organization, Dolvin and Engelmann had to decide where to locate it. They finally chose both countries; Koblenz, Germany would be the site through 1966, when prototypes were expected to be ready, after which the management organization would move to Detroit. While in Germany, U.S. representatives would preside over the JEA/JDT; in the U.S., Germans would assume leadership. Germany thus would house the program during the research and development phase--R&D being its prime concern--while the U.S. would have the program during production--a new tank being the U.S. Army's prime goal.[20]

Negotiating the MBT-70 Requirement

Although most of these arrangements and initial decisions were made by early 1964, members of the JEA and the JDT did not arrive in Koblenz for their first meeting until September 1964, a full year after the program formally began. In part this delay gave the program managers time to staff the organizations they had constructed. In particular, General Dolvin needed the time to select his prime contractor. But the fact was that even in September 1964 the program lacked a firm requirement on which development finally could begin. A task many participants in the project had assumed would take "five or six months" had already taken a year and had yet to produce results.[21] Despite the presence of preliminary analysis stemming from Lockheed Sunnyvale's cost-effectiveness study, the commitment of each army to its preferred tank design concepts and the commitment of each

nation to certain of its own tank components made the task of generating the new tank's requirements a very time consuming negotiating process.

On the U.S. side, there existed a commitment to the basic outlines of the Army's original tank development program. By the time McNamara and von Hassell reached agreement on a joint program the U.S. Army had invested nearly six years in the development of some of the components for that tank. While it had agreed to the joint program, it had done so on the assumption that its previous work would contribute substantially to the joint development. Indeed, some members of the Army's Tank Automotive Command apparently assumed that the joint program would involve little more than a continuation of their component development efforts, perhaps with a certain amount of German "kibitzing" in the background.[22]

On one component in particular the U.S. Army was especially insistent: the Shillelagh antitank missile system. This was a most sophisticated system, one which promised to improve the hit probabilities of U.S. tanks significantly. Development of the Shillelagh had begun in 1957, and promised to cost far more than development of the vehicle that carried it.[23] The service assumed from the start that the Shillelagh's incorporation on board the MBT-70 was axiomatic.[24]

The Army's preference for the Shillelagh system stemmed from a major tenet of the service's tank doctrine. That doctrine called for tank battles at relatively long standoff ranges of 2000 or 3000 meters, ranges at which conventional tank weapons like the 105mm rifled gun on the M-60 did not offer much assurance of hitting enemy tanks. In the 1950s the service had experimented with antitank systems employing missiles *guided* to their targets by means of an infra-red tracking device. This method allowed the gunner to guide the missile by merely keeping his sights on the target throughout the missile's flight. Reliable systems of this sort promised phenomenally high hit probabilities at the ranges envisioned in U.S. Army tank doctrine.[25]

Associated with the range issue was the issue of overall weight. By taking enemy tanks under fire at relatively long ranges, U.S. tanks did not need to rely on high mobility for their survival. In any case,

for this purpose U.S. armor advocates generally preferred additional armor, rather than mobility, picking up mobility by adding engine power rather than subtracting weight and armor. Weight was not a major concern for most U.S. armor officers.[26]

The Bundeswehr had its own tank doctrine, however, which emphasized tank characteristics different from those preferred in the United States.[27] These differences were apparent, for example, in a comparison of selected characteristics of the Leopard I and the U.S. M-60 (see Table 1). To begin with, German doctrine called for tank engagements at close range--around 1000 meters or less--and for high mobility, not more armor plate, to ensure tank survival. Although German officers found the Shillelagh a bit too complex for their liking, they opposed the system largely because they saw no need for it; at the ranges called for in their doctrine, conventional tank guns provided all the hit probability they needed. At those ranges they also wanted high mobility, including secondary road and off-road mobility, to allow them to dart quickly about the battlefield.

Table 1

SELECTED CHARACTERISTICS OF U.S. AND WEST GERMAN TANKS

	Weight (kg)	Pwr/wt (hp/tons)	Height (meters)	Max Road Speed (km/hr)	Cross Country Speed (km/hr)	Nuclear Protection
M60A1	48,100	13.3	3.26	48	25-32	No
Leopard I	40,000	21	2.62	65	40	Yes

SOURCE: *International Defense Review*, Battle Tanks, Special Series, n.d.

High engine power, however, was for them no substitute for light weight. The Bundeswehr felt quite strongly that its tanks should be able to cross the class 50 bridges--bridges capable of supporting about 50 tons--that were found on much of their nation's secondary road network. Here again doctrinal differences gave rise tc differing requirements. Less concerned with pulling away from main highways and large bridges, the U.S. Army preferred a class 60 (60 ton limit) bridging requirement, which thus gave it considerably more leeway in adding weight to its tanks.[28]

The Germans also wanted much more radiological protection for the tank's crew than U.S. armor experts thought was necessary. In the U.S. it was generally agreed that even thin armor could stop most forms of nuclear radiation, while even very thick armor could do little to stop fast neutrons. On these grounds U.S. technical experts effectively ignored the issue. By contrast, the Leopard I had been built to afford its crew some degree of "NBC" (nuclear-biological-chemical) protection and German representatives to the Military Requirements Group insisted on building similar protection into the MBT-70.[29]

Beginning in September 1964, members of the JEA and the JDT met to resolve these differences and to produce jointly agreed final design alternatives for the MBT-70. Yet at the first meeting it became clear that the Germans, too, brought to the project certain commitments to components of their own design. These were not the Bundeswehr's commitments; that army was about to field a new tank, and hence lacked the U.S. Army's preference for new components already under development. Instead, on the German side of the project the commitment came from the contractors themselves, and stemmed from the fact that German engineers retained all rights to their inventions whether working on private or government contracts. This set them apart from their U.S. counterparts, whose contract gave such rights to the U.S. government.[30] And it gave these engineers a personal interest in seeing their inventions incorporated into a production item. Thus, U.S. engineers who traveled to Koblenz fully believing that the Military Requirements Working Group had narrowed the range of alternative tank requirements

to two or three found each German firm advocating its own tank requirements, each requirement employing one or another patented component or design.[31]

Writing the MBT-70 requirement thus involved some effort to accommodate both the commitment of each partner in the project to specific components and design alternatives, and the preference of each army for requirements that stemmed from their differing doctrines of tank deployment. Under these circumstances the PD/CE study does not seem to have played the intended role of "impartial referee" with great success. To be sure, the final Lockheed report appeared in February 1965 and endorsed somewhat different alternatives, each similar to the design preferences of either the U.S. or German Army. And in March 1965 Dolvin and Engelmann announced their agreement on a basic MBT-70 requirement that presumably drew on the Lockheed study. Yet even Dolvin noted that although "the PD/CE Study did play an important role in the decision process. . . , it should be emphasized that it was not the sole source for decision."[32]

Instead, in important respects the MBT-70's basic design seems to have evolved outside this analytic process. On the one hand, basic elements of the U.S. Army's previous tank development projects found their way into the joint requirement. The MBT-70's three-man crew, its automatic loader, the original diesel engine, the hydropneumatic suspension, and the Shillelagh system all carried over from the U.S. Army's to the joint project's guiding requirement. As one U.S. participant put it:

> (I)t appears as if the mass of data generated by the PD/CE Study did not change greatly the design being approached by the unilateral U.S. program which had already been initiated.[33]

On the other hand, major points of disagreement in the requirements debate were solved less by analysis than by simple addition. Although the U.S. Army remained adamant about the Shillelagh, elements within the service saw utility in tank guns of more conventional design. U.S. representatives to the Military Requirements

Working Group thus willingly agreed to develop a conventional kinetic-energy round with a combustible cartridge case that could be fired from the Shillelagh's 152mm gun tube.[34] Meanwhile, they acquiesced to Germany's insistence on providing radiological protection for the tank's crew, though they continued to push for the full panoply of other capabilities inherent in the U.S. Army's own tank requirements.[35] Major conceptual disagreements in this way were shuffled together to achieve agreement on the joint requirement.

The MBT-70's basic design seems to have drawn largely on the original U.S. Army requirement and the compromises that finally stilled conceptual and doctrinal debates between members of the two armed services. As described in *Jane's Weapons Systems*, the MBT-70's basic design was based on

> . . . the concept that an automatic loading device can be used to reduce the crew of a tank from four to three, and that, having done this, all three crew members can be positioned in the turret, which can then be designed for maximum protection from projectile and NBC [nuclear, biological, and chemical] attack.[36]

This basic concept involved a substantial departure from earlier tank design; no major NATO tank had ever housed either the automatic loader, the three-man crew *or* the radiological capsule. In other areas, too, the MBT-70 requirement reached out for new capabilities. The tank was to have a hydropneumatic suspension giving a ride smooth enough to allow the gunner to fire on the move. The suspension was also to allow for raising and lowering the tank's silhouette. The Shillelagh/gun system represented a new departure in tank armament, while the MBT-70's engine requirement called for a substantial increase in power-to-weight ratio over past tank engines.[37]

It is important to note that the tank's final requirement was more complex and risky than either army would have pursued if left to itself. The U.S. Army would have dropped the idea of a radiologically protective capsule in the vehicle's turret, paving the way for a lighter tank, or, more likely, for the possibility of adding weight elsewhere.[38] The Bundeswehr, on the other hand, would have scuttled

the laser-guided antitank missile in favor of a more conventional tank gun. The process of negotiating the MBT-70's requirement in this sense tended to push the tank's design to higher levels of complexity. At the time, this seems to have gone unnoticed, perhaps because the tank's final requirement was written on paper only, and this took little effort. As one German observer put it some years later, "(t)he complexity of the system. . . was hardly considered when the joint military characteristics (MCs) were agreed on."[39]

This approach to the tank's design would have been more appropriate, perhaps, had the program's development cost and completion date not been cited in the 1963 agreement. To be sure, the funding limit of $100 million was flexible, some estimate being needed to get the program started.[40] But the completion date was anything but flexible; the U.S. Army needed a new tank, and both it and McNamara felt strongly that the December 1969 production deadline had to be met.[41] Both cost and schedule requirements had been written before either partner had a clear idea of what the new tank would look like. Yet the very manner in which the joint requirements were negotiated made it even less likely that either the cost or the scheduling requirement would be met.

BUILDING THE PROTOTYPES: PATTERNS OF DECISIONMAKING

Until March of 1965, when the joint requirement finally had been pieced together, U.S. and German participants in the MBT-70 project had been able to achieve what they wanted from the program. This came out most clearly in those fundamental compromises that established the MBT-70's basic design. But until that date, that design was on paper only. The MBT-70's actual development sought to take this design from paper to hardware. Hardware, however, could not easily be made to give each nation what it sought. Indeed, as soon as hardware development began, collaboration began to end. By the time prototypes first appeared, the program's joint nature was seriously in jeopardy.

There never really occurred much that could be called "joint" development, in the sense of German and U.S. designers laboring over the same drawing board.[42] The U.S. Army had prior commitments to

components of its own already under development, and to the extent that these components, or upgraded versions of them, were included in the joint requirement, there was every reason to continue their development on a unilateral basis. This proved acceptable to the Germans, whose vested interest in patent rights made them quite reluctant to cooperate in any case. Under these circumstances the program broke down immediately into separate component developments carried out on a national basis. Only the hull and turret layouts were designed jointly.[43]

Development of individual components was assigned, Dolvin later recalled, "on [the basis of] technical preeminence in that area . . . However, political and economic considerations did manage to play a part in some selections."[44] In general, the United States acquired responsibility for a few of the more technically advanced components--the Shillelagh/gun system,[45] the variable-compression ratio diesel engine, and the primary fire control loop. The Federal Republic took responsibility for more systems of somewhat lesser technical difficulty--the tank's secondary armament and fire control loop, the transmission, automatic loader and suspension.[46]

This breakdown would have been quite in keeping with the general notion of a "joint" program had only one set of components, and hence one tank, been developed. But though this may have been the expectation, it was never the reality. Instead, some component developments were duplicated from the very start. Although the United States set to work on the tank's engine, the joint program also funded Germany's work, at Daimler-Benz, on a less sophisticated alternative design.[47] Both nations likewise pursued parallel development work on alternative suspension systems. At the time, this duplication was dismissed either as a useful way of hedging against the risk of failure in a primary development, or as an effort to develop new components for incorporation in later versions of the MBT-70.[48] But it seems likely that in fact the "political and economic considerations" Dolvin alluded to apparently came into play here, as the U.S. Army continued some of its component work and Germany sought to give its industry experience and skill in the tank field.[49]

As it happened, development of some of the primary components ran into severe technical difficulties. The Shillelagh took much longer to develop than anyone expected, for example, as problems arose in trying to stabilize the system in the tank's turret, and in getting the gun cartridge's combustible case to burn fully before the breech opened to accept the next round.[50] Meanwhile, by 1966 the U.S. engine contractor had run into real problems meeting the program's power demands.[51] And the Germans found it impossible to achieve reliable operation of their automatic loader.[52] These were all technically complex components; their development could not be accomplished trouble free.

Technical problems in primary components became the basis for still more duplication. With the U.S. engine development in trouble, Germany moved the Daimler-Benz engine higher on its list or priorities, until by 1968 that engine outperformed its U.S. competitor. Rather than agree to mount the Daimler-Benz engine in its tanks, however, the U.S. raised a turbine engine development project from relative obscurity to a higher point on *its* list of priorities.[53] And in response to the Shillelagh's problems the Germans initiated development of a more conventional 120mm gun.[54] The "joint" program thus began to look increasingly like the component development program it presumably had replaced.

Meanwhile, the tank's weight had begun to climb as the weight of candidate components rose during their development and the compromise between having radiological protection and more armor began to take its toll in pounds. The U.S. saw these weight increases as a reasonable price to pay for having more armor protection. The Bundeswehr disagreed. This major point of contention rose to the ministerial level, where it was resolved in a way curiously akin to the "duplicative developments" solution to other disagreements. While the allowable weight limit was raised, the program was placed on a crash diet in an effort to reduce weight where possible, without compromising other requirements.[55]

At this point the prospect of getting one standardized tank from the program had dimmed considerably. By the time initial pilot models

of the MBT-70 appeared late in 1967 and early the next year, it seemed fairly clear that on critical issues the U.S. and the FRG had parted ways. This was especially true for the gun and engine, the two most important components as far as standardization, maintenance, and supply were concerned. Some prototypes sported the Daimler-Benz engine, while some contained the U.S. engine, and though the Shillelagh was on all pilots, it seemed likely that the German 120mm gun ultimately would replace it on Germany's version of the MBT-70. Duplication thus undermined the program's original goals.

"Matters which had been negotiated and discussed and agreed upon," General Dolvin later remarked, "for some reason, would reappear for renegotiation at later dates."[56] Indeed they did. But the pattern of decisionmaking had not really changed--the same pattern of compromise marked the program from start to finish. What changed was the material over which those compromises had to be worked. It was easy enough to make the tank's *requirement* all things to all people, but quite another thing to develop an *actual tank* for all interested parties. The two tanks inherent in the joint requirement thus began to emerge in prototype form. What could be written on paper could not be embodied in hardware, and as this became clear, the project disintegrated.

DISSOLUTION

Although the first MBT-70 prototypes demonstrated real promise, by the time they appeared the program had already begun to dissolve, as hardware construction made it increasingly difficult to contain differences that had plagued the program from its very beginning. These differences lay behind the move to duplicate the development of critical components. The program's dissolution completed this logic, as by 1970 each nation moved from parallel development of separate components to parallel and separate development of two new tanks.

In the end the differences that drove the two nations apart related quite directly to the different tank requirements each army brought with it to the joint program, as well as the different goals

each nation sought in the project. But because rising costs also played an important role in sparking the program's demise, and because the costs of collaboration remain a matter of some importance, this section will look first at changes in the program's cost and schedule and in the influence collaboration itself wielded over these changes. It then will turn to the lingering conceptual differences that ultimately drove the two nations apart.

Collaboration and Rising Costs

Problems surround any discussion of the MBT-70 program's cost and schedule. Because the tank was never produced, when and at what cost it could have been produced remain to this day debatable matters. The cost of the tank's development also is debatable, since that development was never fully completed and in any case came to include work on a variety of subcomponents that might never have found their way into the finished vehicle. Finally, it is utterly impossible to separate the costs of collaboration per se from the costs of developing the MBT-70 on a purely national basis. For the most part, then, this subsection will refer to projected development cost and completion date, and although it will outline those elements of the collaborative process that helped drive costs upward, it will fall short of measuring the extent of their influence.

Table 2 shows the program's estimated completion date and development cost as they changed over the course of the program. It includes the U.S. Army's final estimate for development of the XM-803, the austere version of the MBT-70 it constructed after the FRG left the collaborative program in 1970. In total, the United States spent $305.4 million on the MBT-70/XM-803 before the entire program was terminated in FY1972; $231.1 million of this was for R&D, while $74.3 went for procurement.[57] The FRG spent approximately $100 million as its share of the MBT-70 program.[58] Because the breakdown between R&D and procurement for the FRG figure is not available, it is impossible to cite with precision the overall cost overrun for the program. Clearly such an overrun existed, however, and probably exceeded 200%.[59]

Table 2

CHANGING COST AND SCHEDULE ESTIMATES FOR THE MBT-70 AND MBT-70/XM-803 PROGRAMS, 1963-1970

Date of Estimate	Estimated Development Cost ($ millions)	Estimated Prototype Completion	Estimated Production Date, First Vehicle
August 1963	$80 - $100[a]	January 1967	December 1969
August 1965	$138[a]	--	--
December 1966	$200[a]	July 1967	December 1970
September 1967	--	--	December 1971
March 1968	$300[a]	--[b]	--
June 1970	$267.5[c]	--	--

SOURCES: Sheridan, "U.S./FRG Main Battle Tank," pp. 44, 47. U.S. General Accounting Office, "MBT-70 Weapon System," March 1971.

[a]Includes U.S. and FRG shares of R&D costs.

[b]The first U.S. prototype appeared in July 1967 as scheduled; it was not ready for testing at that time, however.

[c]U.S. estimate for completion of MBT-70/XM-803 development; excludes FRG R&D expenditures of about $100 million on MBT-70 prior to the end of the collaborative effort in 1970.

To some extent, the program's cost overruns resulted from bad initial predictions. The $80 million baseline estimate that McNamara sought to have written into the 1963 agreement was considered unrealistic at the time even by most participants in the negotiations. Never comfortable with this figure, the Germans insisted on adding to that agreement a proviso establishing a range for the baseline estimate of from $80 million to $100 million.[60] U.S. Army representatives argued that while unilateral development of the MBT-70 might cost about $85 million, collaboration would drive the price to $120 million.[61] All of these figures, however, were seen as "soft" estimates to U.S. participants in the joint program. A much harder estimate of $138 million appeared in August of 1965, after Lockheed had completed its design study and a detailed requirement had been written. Yet this harder baseline estimate was revised still further in December of 1966.

It is impossible to cite with precision the forces that pushed the program's cost upward, its schedule outward. This is particularly true when it comes to the technical problems that cropped up as development proceeded. Although negotiating a joint requirement had added its own element of risk and sophistication to the tank's Military Characteristics, even the U.S. Army's original requirement had been an ambitious one. Furthermore, in many cases representatives from both nations had willingly agreed to increase the project's risks in order to exploit technology to the fullest. It is simply impossible to apportion the responsibility for technical problems and the cost overruns they produced to either source of risk in the tank's requirement.

Nonetheless, it is possible to point to a variety of ways in which collaboration itself spurred the program's costs upward. Duplication in the development process stands out as a problem that derived largely from each nation's need to meet its own requirements--not simply military requirements, though these were compelling enough, but industrial and political requirements as well. Significantly, early cost estimates were based on the assumption that no duplication would arise.[62] That duplication not only arose but increased as development progressed no doubt helped raise the program's costs over initial estimates.[63]

But duplication was only the outward manifestation of an underlying problem that stemmed from the fact of collaboration and had its own effect on the tank's development costs. For the intricate framework that bound the two partners to one another seems to have prevented them from backing away from requirements that proved difficult and expensive to meet. One way to halt cost increases is to forgo goals that prove expensive to reach. But in the MBT-70 project the original requirement had been the result of nearly two years of painstaking negotiations. It contained the sometimes competing needs of the two armies. And it had become the basis for a rather elaborate set of work-sharing arrangements that balanced the partners' needs and goals. All of these facts made it difficult to change the requirements. Renegotiating the tank's maximum weight, for example,

took a decision at the ministerial level. Duplication, not tradeoffs in the original requirement, became the accepted method for dealing with technical problems.

Finally, costs rose as a result of collaboration insofar as virtually everything took longer than expected. Language differences alone made a sizeable contribution to this problem. Dolvin, for example, recalls haggling over a technical issue for two hours before it become clear that the real problem lay in the mistranslation of a key concept.[64] Problems such as this, spread over a multitude of discussions covering the tank's design, absorbed much energy and time for the project's participants.

In addition to problems with language were those stemming from the need to negotiate virtually all decisions, as exemplified by the debates that extended the requirements process. In fact, the two partners had to negotiate issues that would not even have arisen in a national project. The use of inches or metric measurements in the tank's design, for example, became a major point of contention, one that traveled to the ministerial level for resolution.[65] Although even national projects involve a certain amount of negotiation, the widely divergent interests and concepts Germans and Americans brought to the MBT-70 project combined with language differences to stretch these negotiations beyond what anyone had expected. And because wasted time costs money, these problems took a toll from the program's cost as well as its schedule.

Whatever its cause, the rising cost of the MBT-70 program began to create funding problems on both sides of the Atlantic by 1968. In Germany the Defense Ministry found it increasingly difficult to cover the program's actual cost. As part of a parliamentary system of government, the German Defense Ministry received block sums of money on a five-year basis to cover developments like the MBT-70 program, and it was difficult to get more than the allotted sum once the allotment had been made.[66] Thus the 50-50 cost-sharing formula broke down by 1965, as the U.S. agreed to pay $85 million to Germany's $53 million of the estimated $138 million development cost agreed to in August of that year. Germany agreed to the $300 million cost

estimate computed three years later, but ministers from each nation had to negotiate another cost-sharing formula.[67] Germany's commitment to the program seemed to be wavering. Meanwhile, in the United States rising costs and scheduling delays provoked a Congressional investigation that began in August of 1968.[68]

From Duplication to Dissolution

Rising costs also raised questions about the wisdom of the MBT-70's original requirement, questions now informed by an understanding of the enormous problems encountered in trying to meet that requirement. With rising costs as a backdrop, each nation tended to see its problems as embodied in the strictures its partner had placed on the joint requirement. By 1968 duplication had become the accepted way of dealing with these differences. After 1968 the partners carried this approach to its extreme, as each agreed to pursue its own requirement in its own tank development.

At the top of the list of requirements differences that nettled the Federal Republic lay the schedule project completion date. Production versions of the Bundeswehr's Leopard I went to German armor units in 1965 and immediately became popular with the troops.[69] From that point on the FRG had no need for a new tank until 1975. Escalating costs thus grew increasingly irksome, especially when some portion of that cost escalation no doubt derived from the U.S. desire to solve the tank's problems quickly in order to meet U.S. Army needs. Germany had the time to solve these problems in a more orderly, less hurried and presumably less expensive manner. Indeed, it had the time to develop an entire tank on its own if need be.

It also had the components to develop such a tank. The original work-sharing arrangements, it should be recalled, gave the Federal Republic more components to develop than the United States.[70] Since those work-sharing arrangements had been negotiated, the FRG had initiated parallel developments of critical items like the conventional tank gun and the Daimler-Benz diesel engine. By 1968 this gave Germany most of the parts needed for a tank of its own design.

Lacking any compelling reason for staying in the program, the Bundeswehr found it difficult to accept certain aspects of the tank concept embodied in the MBT-70 prototypes. The Germans had preferred a standard tank gun to the complex Shillelagh's missile system all along, and found it increasingky difficult to await resolution of the weapon's persistent technical problems. More important, the prototypes came in overweight. Indeed, the vehicle was not only too heavy but also too wide to cross Germany's class 50 bridges.[71] The Germans took the issue very seriously; their project manager declared that the tank's weight problems "very seriously endangered" the project's continuation as a joint venture.[72]

Ostensibly as a result of these problems, the Federal Republic announced in April of 1969 its intention to design and build a tank of radically different design than the MBT-70's. Although the Bundeswehr would still buy some MBT-70s, it would need far fewer than it originally intended to buy. Joint funding of the project came to an end, and the two nations agreed only to "continue the joint program under a policy of maximum commonality consistent with national interest."[73]

In need of a new tank, U.S. Army officers were less vocal than the Germans about their problems with the MBT-70 program. Still, the following comment by one U.S. participant in the joint program suggests that they, too, had conceptual problems with the prototypes:

> To my way of thinking the requirements of the U.S. Army should not be subordinated to those of a joint program just to keep the program alive. When a program arrives at a point where an acceptable compromise cannot be made between the partners, the program should be terminated. There could be nothing worse than one army or the other being forced to accept a piece of jointly developed equipment that did not meet its own requirements. U.S. Army priority requirements for a piece of equipment must not be sacrificed for the sake of a politically desirable international program.[74]

In addition to the Army, by 1969 the Office of the Secretary of Defense, now headed by a new Secretary, began to question the wisdom

of continuing the program. Costs played a major role in OSD's thinking. In that year it queried the Army about the tank's expense, asking whether it would be wise to plan for a one-for-one replacement of M-60s with MBT-70s.[75] And in September of that year Deputy Secretary of Defense David Packard expressed to Congress his concern for the tank's complexity:

> I suggest that the entire program be reviewed with particular emphasis on the question of what simplifications should be made in the design itself, how the program management could be improved, and what other possibilities there might be to bring the program into a more satisfactory position from which we might move ahead.[76]

The program's cost also had begun to incur more criticism in the U.S. Congress. In particular, the House Appropriations Committee found the project much too expensive. The Committee's members were especially interested in the possibility of placing the Shillelagh on board an M-60, gaining some of the MBT-70's capabilities at much less cost.[77] On these grounds, the House cut a small amount of the project's R&D money from the FY1970 budget. Meanwhile, the House Armed Services Committee began to push for a modified M-60, and further development of an "austere" MBT-70.[78]

In January of 1970 the collaborative project formally dissolved, as David Packard announced a revision to the 1963 agreement in which each nation assumed "unilateral technical decisions and unilateral funding, while continuing to cooperate to achieve a measure of commonality in the future tanks programs of the two countries."[79] The FRG, of course, had been working on a new tank design for nearly a year, and at this point dropped the idea of buying any MBT-70s. In the U.S., on the other hand, the program continued under Packard's announced guidance to simplify the design where possible. It also took a new name, the XM-803 program.

But the MBT-70's basic design apparently would not cater to much simplification, at least not within the cost constraints then being imposed on it. The automatic loader could not be replaced with a fourth crew member, for example, unless the driver were moved from

the turret into the hull. But this would have also made it necessary to eliminate the protective capsule that had driven the original design. The turret had in any case been designed to accept the Shillelagh, and eliminating this system would have made necessary still more modification to the turret. Thus, although the XM-803 prototypes represented reasonably good tanks, they were neither very simple nor very cheap. Army estimates placed the tank's cost, for example, at anywhere from $850,000 to $1 million per tank.[80]

In any case, by this time influential elements of the U.S. Army armor community had slowly begun to change their minds about the wisdom of mounting missile systems on tanks.[81] New developments in kinetic energy rounds with impressive armor-piercing capabilities spurred this process, as did the Shillelagh's complexity, unreliability, and expense. The XM-803 thus lacked unanimous Army support, and this made it hard to justify the program in the Congress.

With the XM-803's expense and the Army indecision in the foreground, Congress finally cancelled the entire program in December 1971.[82] In place of funds for further development of the XM-803, the Congress appropriated $20 million to cover termination of that program and to begin the development of an entirely new tank: the XM-1.[83]

CONCLUSION

Those who cite the importance of requirements as a guide to collaborative ventures do so for the obvious reason that collaboration "from the ground up" must be given initial direction by some agreed upon notion of where the project is going. But the MBT-70 experience points up the importance of seeing these joint requirements as nothing more than goals. In the case of a very ambitious set of requirements, those goals may have to be compromised if technology cannot be made to yield the required performance at a reasonable price or within a reasonable time period. This was the case with the MBT-70, a case in which the establishment of a joint requirement merely initiated a very trying process of negotiating between that requirement and technology, money and time.

Collaboration in this case added its share of sophistication and risk to the original joint requirement, while it contributed to the difficulties associated with backing away from requirements that proved difficult to meet. On the one hand, because neither military service wanted to sacrifice its own military requirements, the joint requirements process tended to be additive in nature. Rather than make hard choices among requirements, negotiators from each country simply added requirements together, making the initial joint requirements that much more ambitious. On the other hand, once these requirements had been agreed upon, and even more so after they had become the basis for work-sharing arrangements, they became difficult to change. Tampering with the original requirement, after all, threatened to upset a fairly delicate balance of competing military, political, and industrial interests. So the partners tried to meet the initial requirement--at some expense--while they also started duplicate backup developments outside the initial work arrangements--at still more expense. And finally, when technology would not fully yield the tank each partner wanted at a cost either could afford, the program dissolved.

One way to alleviate some of these problems might be to organize collaborative development programs around a single executive capable of making and enforcing design tradeoffs in a way that Dolvin and Engelmann, their power shared, never could. Whether or not two or more nations could agree to such organizational arrangements remains debatable. Especially in the case of a major system, one that is, like the tank, both expensive and important to each participating service, there is reason to doubt that any nation would cede its rights to some say in the system's development. In such cases even an organizational structure that formally consolidated power in a single decisionmaker might mask negotiating over requirements and design tradeoffs much like that which marked the MBT-70's development. A single case study does not provide much insight into the feasibility of alternative organizational arrangements. The MBT-70's history can only illustrate the problems inherent in one such organization.

Setting aside the question of organizational structure, two other solutions to the problem that marred the MBT-70's development suggest themselves, yet the MBT-70 experience casts some doubt on the effectiveness of each. On the one hand, nations anxious to collaborate could, by choosing low risk systems, reduce or even eliminate the need to compromise the initial requirement during the development process. Although this is true enough, in the MBT-70 program the process of negotiating a joint requirement was itself responsible for adding an element of risk to that tank's requirement. To the extent that this holds true for other "ground up" collaborative ventures, there is no guarantee that partners desiring a low risk development will in collaboration produce a low risk requirement.

On the other hand, nations could choose to collaborate only on systems where their requirements are identical. Here, however, the MBT-70 experience suggests two potential problems. First, if tradeoffs are to be made in the development process, partners must agree not only on requirements but on priorities. That two armies agree on a given system configuration does not guarantee that they will agree on what should be given up *first* if that configuration must be modified. Second, the MBT-70 case suggests that it is not easy to know if requirements are truly aligned until after development has begun. Agreement achieved on paper may dissolve after prototypes have appeared.

If developing major systems from the ground up faces these hazards, of course, one final solution is to engage in collaboration of lesser degree involving systems developed or partially developed on a national basis. This is in fact the course Germany and the United States have taken in the wake of the MBT-70 program's termination. It is to the lessons of this more recent experience that I turn in the next section.

III. HARMONIZING TANKS: U.S.-GERMAN COLLABORATION SINCE 1970

After 1970 the U.S. Army and the Bundeswehr forged ahead on national tank development programs; the question of collaboration in the design of a single tank was not given serious consideration. Cooperation between the United States and Germany in the tank area centered instead around licensed production of the German Leopard 11 for U.S. Army use, or, failing that, "harmonization" of the two new tanks through an exchange of components aimed at giving them common features--guns, engines, and the like. The second of these two collaborative arrangements is now embodied in an agreement that, if successfully implemented, will result most notably in standardization of tank guns and ammunition. The agreement thus could have important implications for logistics and combat effectiveness within NATO.

There has been some political debate within both countries surrounding the importance of these efforts, but only in the United States has this debate actually questioned their value. Germany has for the most part acted aggressively and single-mindedly throughout the period. In possession of a resurgent economy and reasonably strong military R&D capabilities, the Germans sought in the 1970s to gain a voice in the Atlantic Alliance commensurate with what they feel is their political and military power. They have been especially insistent with the U.S. on the subject of offsets for their purchase of U.S. military products--on creation of the so-called "two-way street." When it comes to tanks, the German Parliament has in general acted to reaffirm, rather than question, military policy aimed at reaching these goals.

The reverse has been true in the United States. Although the XM-1 project began as a strictly national development, in 1973 the Secretary of Defense and his staff (the Office of the Secretary of Defense--OSD) began to seek ways of using the XM-1 program in an effort both to accrue the benefits of standardization and to create a two-way street with the FRG. But because their activities threatened the tank's cost and development schedule, they were opposed by those in the Congress who preferred to see the XM-1 program meet the

cost and schedule goals set out for it in 1972. Although much of the record of the debate between OSD and these Congressmen focused on the military value of the Leopard II and the German tank gun, behind this lay a more fundamental debate over the real value of cooperation within the alliance.

Although strictly a domestic affair, this debate affected the shape of U.S.-German collaboration. In particular, the relationship between the ongoing XM-1 program and efforts to mount the German 120mm gun on the tank were influenced in scope and timing by strong pressure from the Congress to keep the XM-1 program moving as originally planned. Collaboration thus has been a political "outcome," a product of compromises between members of two branches of the U.S. government having different views on whether and how collaboration should be implemented.

The story of U.S.-German collaboration since 1970 thus is largely the story of how this outcome emerged. This chapter outlines that story and suggests some of its implications for further cooperation along lines similar to those taken in the tank area. It focuses first on the guidelines set out by the Congress for the XM-1 program in 1971 and 1972 and the U.S. Army's efforts to structure and manage the program with those guidelines in mind. It then turns to OSD's efforts after 1973 to effect some form of cooperation within the XM-1 program, and to the debate that has surrounded those efforts. Finally, it concludes by outlining some of the implications of that debate for both future tank collaboration and collaboration on other systems.

CONGRESS, THE ARMY, AND THE XM-1

Behind the political debate that came to surround efforts to introduce collaboration into the XM-1 program lay Congressional interest in seeing the Army's new tank developed as fast and as economically as possible. Key members of the House Armed Services and Appropriations Committees had become increasingly interested in Army tank programs after 1968, first criticizing the MBT-70 program, then working to cancel the XM-803 project, and, finally, appropriating funds for initial work on the XM-1. The criticism they leveled at

the XM-803, coupled with the language they inserted in the appropriations bill that initially funded the XM-1, formed a set of fairly clear guidelines for the XM-1's development that the U.S. Army thereafter followed in structuring and managing the project. Because the development program thus shaped was meant to proceed briskly and under fairly stringent cost guidelines, however, it did not possess the inherent flexibility members of OSD would require later on, when they became interested in collaborating, once again, with the FRG in the tank realm. That such collaboration was both criticized and delayed in the Congress derived in large part from the way in which the XM-1 program began.

Most of the active opposition in the Congress to continuing the XM-803 program came from the House Appropriations and Armed Services Committees, which were primarily responsible for arranging cancellation of the XM-803 and also for having funds appropriated for a new tank project. The guidelines these committees passed on to the service concerning the XM-1's development took the form of criticism of the XM-803, as well as general instructions on how to spend the newly appropriated funds.

Criticism of the XM-803 focused on what were perceived to be the tank's two major problems. On the one hand, the tank itself was, in the House Appropriations Committee's language, "unnecessarily complex, excessively sophisticated, and too expensive."[1] Although there remained some ambiguity as to what in the Appropriations Committee's opinion might be an appropriate price for a new tank, at one point the Committee suggested that such a vehicle should cost "about a third of the cost now estimated for the current [XM-803] design."[2] On the other hand, criticism also held that the XM-803 had been too long in development. On this point the House Appropriations Committee was especially adamant. Its FY1973 hearings contain criticisms like this one, lodged by John Rhodes (R-Arizona):

> If it takes 8 to 10 years to develop a new tank, it will be 12 to 14 years before it is in production and deployed in the field. By that time it will probably be obsolete . . . [The Army] had better get the person who built the Model T Ford. This is ridiculous.[3]

Criticisms like these implicitly warned the service to be very careful about the cost and development schedule of its next tank.

But these Committees did more than criticize. At the same time that it recommended cancellation of additional funding for the XM-803, the House Appropriations Committee recommended the appropriation of $20 million "for the purpose of initiating a prototype program to build a limited number of tanks of two different designs for tests and evaluation."[4] In the same report, the Committee commended the MBT-70's armor and fire control system to the Army's attention, but criticized that tank's ability to raise and lower itself, its automatic loader, and its Shillelagh antitank missile system as sources of excessive cost and complexity.[5] The report thus expressed the Committee's preference for a simpler and cheaper tank than the MBT-70/XM-803, and for a development program that would employ competition to control the project's costs and schedule. By including the report's language in its FY1972 Appropriations Bill, the Congress formally passed on to the service the Committee's advice and instruction.[6]

Mindful of the Congress' instructions and its concern for the XM-1's cost and development schedule, the service took steps to structure the XM-1 program and manage the tank's development in ways that would meet with Congressional approval. Three aspects of the program evidence most clearly the Army's concern for its costs and development schedule: the XM-1 requirement, the program's initial structure, and the Army's managerial approach to the tank's early development.

The task of writing the XM-1 requirement fell to a committee of officers especially convened in January 1972 to handle the task, a group called the "Main Battle Tank Task Force."[7] After first concluding that the tank still served an important purpose in modern combat,[8] the Task Force turned to writing the specific requirement for a new tank. In undertaking this task, it sought to control the tank's cost and development schedule in two ways.

First, with help from other members of the Army Staff, the Task Force established a unit cost goal for the new tank of $507,000 ($72), higher than the M-60's unit cost but lower than the Army's final

estimated unit cost for the XM-803. Thereafter, the Task Force sought to hold the unit cost attached to its tank requirement to that mark. This produced a series of tradeoffs in the requirements process; additions to the tank's requirement that drove its price tag over the unit cost goal had to be compensated by the deletion of other requirements that returned the tank's cost to $507,000.[9]

Second, the Task Force sought to control the new tank's cost and development schedule by limiting the degree of risk inherent in its requirement. Although it used computer simulations to test some new tank concepts, the Task Force concentrated for the most part on cataloging available tank components that could be used by prospective contractors in designing their tanks. To find their way into the catalog, components had to be available in hardware form and to have undergone a certain amount of testing. In some cases the Task Force used part of the $20 million appropriated to the service in the FY1972 Appropriations Bill to test further new components before adding them to the catalog. The goal, as one member of the Task Force put it, was to "make components available for selection by the contractors with moderate risk, so that we would not have to start all over again. . . ."[10]

Significantly, there existed some doubt initially as to whether the service could at once control the program's risks--and thereby its cost and development schedule--yet still field a tank sufficiently better in performance than an improved M-60 as to make the new project worthwhile. These doubts were allayed by the Task Force's discovery of a new armor of British origin then under examination at the Army's Ballistics Research Laboratory. This so-called "special armor" promised sizable improvements in survivability over equal weights of the M-60's armor. Hence, the Task Force funded the armor's further test and development, and finally added it to the XM-1 components catalog. To a great extent this armor provided the rationale for going ahead with the XM-1 project.[11]

With the XM-1's requirement completed by summer of 1972, the service began structuring a program that met with Congressional guidelines. In July of 1972 the service established the XM-1 Project

Manager's Office at its Tank Automotive Command in Warren, Michigan. And in November it presented its program proposal, to include the requirement generated by the Main Battle Tank Task Force, to the Defense Systems Acquisition Review Council (DSARC). With DSARC approval coming in January 1973, the service published the XM-1 Request for Proposal (RFP), and in June of that year it awarded Chrysler and General Motors contracts to develop competitively their own designs for the new tank. The service scheduled test and evaluation for spring 1976, with source selection and the award of an engineering development contract slated for July of that year (see Table 3).[12]

Table 3

XM-1 PROGRAM: PROJECTED SCHEDULE

Program Office Established	July 1972
DSARC I	January 1973
RFP Published	January 1973
Contract Award	June 1973
Prototype Construction and Validation	June 1973 - July 1976
Development/Operational Testing I	February - March 1976
DSARC II/Source Selection	July 1976
Engineering Development Phase	July 1976 - June 1979
Development/Operational Testing II	August 1977 - June 1979
Low Rate Initial Production	August 1979 - June 1980
Full Production Decisions	August 1980

SOURCE: Senate, Committee on Armed Services, Subcommittee on Research and Development, *FY1976 and July-September 1976 Transition Period Authorizations, Hearings*, Part 6, 94th Cong., 1st Sess., p. 3171.

Once development of the XM-1 prototypes began, the first XM-1 Program Manager, Brigadier General Robert J. Baer, employed "design-to-cost" managerial techniques in an effort to keep the tank's unit cost at or below the $507,000 limit. "Design-to costs," Baer told the Senate Armed Services Committee early in 1973

> must be met, even if the performance is reduced. We are telling [the contractor] he has to make tradeoffs of performance in those areas which he thinks they can be best afforded in order to maintain the cost consideration.[13]

To help contractors select the appropriate tradeoffs, contracts specified the service's priorities in tank performance, as well as "bands" of performance within which the contractors were given flexibility to make appropriate tradeoffs.[14]

Because changes in a system's initial requirement often have been a source of cost increases as development proceeds, General Baer obtained agreement with the Army's Training and Doctrine Command, the service's "user" agency, to delay changing the XM-1 requirement until the full-scale development RFP was published in October 1975. To the extent that new requirements were added to the original requirement, those suggesting additions were asked to suggest compensating deletions. In this way, the XM-1 contractors were given a relatively stable requirement on which to work.[15]

As in the case of the program's requirement and structure, the use of these managerial techniques was influenced by the role Congress played in cancelling the MBT-70/XM-803 program. Key servicemen and engineers involved in managing the program genuinely feared that schedule slippage would lead the Congress to cancel once again the service's tank program. "On schedule, on cost" was the project's theme from the very start of the program. Thus, although costs are important in most development programs and design-to-cost techniques have been applied to weapons projects besides the XM-1 program, in this particular case the service's recent experience with the MBT-70/XM-803 program made it especially important to use those techniques in keeping the XM-1 program within limits acceptable to the Congress.[16]

THE QUESTION OF COLLABORATION AND THE XM-1, 1972-1974

It is important to note that from its inception through 1974 the XM-1 program involved no cooperation with a NATO ally. In part, this reflected a general disillusionment in the Congress and OSD with the collaborative process. In the Congress, for example, those who criticized the MBT-70/XM-803 program blamed some of its problems on the vicissitudes of joint development. In recommending cancellation of the collaborative Mallard communications system development in 1969, for example, the House Appropriations Committee noted that ". . . joint international development programs are inherently turbulent and trouble-ridden. The most recent example is the MBT-70 development program. . . ."[17] Interviews in 1972 with staff members of the House Armed Services Committee produced agreement that "joint development (with West Germany) just didn't work. We ended up with three engines, three transmissions, and two or three secondary weapons systems."[18] And in the Senate, Richard Russell of the Appropriations Committee also "questioned the wisdom of the German-American joint development."[19]

Similar doubts were evident in the Defense Department. In terminating the MBT-70 program in 1970, for example, Deputy Defense Secretary David Packard noted that

> It was clear to me that the joint nature of the program made decisions most difficult and that reorientation of the program along the lines I desired would be impossible without a major change in the joint program. Accordingly, I directed that we take steps to establish unilateral technical decision authority and to terminate joint funding of the program as of 31 December 1969.[20]

There is no evidence of any pressure from either the Congress or OSD to take steps to cooperate with the FRG at the time the XM-1 program was getting started.

To be sure, the U.S. Army considered outright purchases of the Leopard II, as well as the purchase of its 120mm smoothbore gun. In both cases, however, concern for the cost and development schedule of the Army's new tank militated against the selection of either the

German tank or its gun. After examining the Leopard II in 1972, the Army concluded that it was too expensive and complex. Lacking the special armor then being considered for the XM-1, the German tank also fell short in the survivability category.[21]

A number of considerations led the service and its contractors to favor the Army's standard 105mm gun over Germany's 120mm smoothbore gun. To begin with, the 105mm gun was "the smallest, lightest, and least costly gun adequate for the job."[22] Indeed, new kinetic energy ammunition for the weapon then under development at the Army's Picatinny Arsenal promised to extend the gun's usefulness well into the future.[23] And because the Army's other tanks, the M-60 and the upgraded M-48, as well as the tanks of virtually every other NATO nation, used the 105mm gun, mounting that gun on the XM-1 promised to increase standardization within the alliance. Moreover, continuing development of the new ammunition for the XM-1 automatically upgraded every other gun in NATO.[24] For all of these reasons the XM-1's development proceeded "on the assumption that the 105mm gun would probably be the eventual main armament."[25]

Cost considerations thus helped make the XM-1 program a purely national effort at its inception, just as concern for the new tank's cost and development schedule critically influenced the tank's requirement and the program's structure and management. As the tank's development progressed, the same set of considerations shaped the approach both the service and key members of the Congress took to the Defense Department's initial efforts to introduce collaboration with the FRG into the program.

FIRST STEPS TOWARD COLLABORATION

In 1973, after the XM-1 program had begun, the Secretary of Defense and his staff first broached the idea of introducing some degree of collaboration into the Army's tank program. Their professed goal was to reap the presumed military and economic benefits of standardization (or "harmonization" as it later was called).[26] The specific form collaboration would take remained unclear at the time; in these early years OSD sought merely to open possibilities

for standardizing in some degree the main battle tanks then under development in the U.S., the FRG and the UK. OSD's goals and designs for collaboration were embodied in two agreements signed in 1974.

However nebulous were the possible forms of collaboration articulated in these agreements, each seemed likely to necessitate changes in the cost and scheduling of the U.S. Army's tank program. Thus in 1975, as the ramifications of each agreement grew more clear, there arose the first signs of tension between Congressional guidelines and the demands of the collaborative process as formulated by OSD. At this point Congressional guidelines shaped the collaborative process. Later, in 1976, the needs of the collaborative process would change the shape of the XM-1 program.

The Agreements of 1974

OSD's interest in collaboration in the tank area first arose in June 1973 at a NATO Defense Planning Committee meeting held in Brussels. While there, German Defense Minister Georg Leber and U.S. Secretary of Defense-designate James Schlesinger discussed the possibility of standardizing tank guns within the alliance, as well as the possibility for a wider degree of standardization between the XM-1 and Germany's Leopard II. Leber also expressed an interest in seeing his nation's tank compete against the XM-1 prototypes as a candidate for acquisition by the U.S. Army.[27] Schlesinger summarized the substance of these discussions in a letter to Leber dated 28 September 1973:

> I feel that the efforts I have discussed should lead toward greater standardization, especially in the main armament, and even possibly toward a final evaluation that one of the tanks could meet the needs of both our armies.[28]

Soon after this letter was written a team of U.S. negotiators traveled to Europe, where over the next fifteen months they concluded two agreements that formalized the ideas Leber and Schlesinger had discussed.

The first agreement, concluded in March 1974, was a trilateral memorandum of understanding (MOU) in which the U.S., FRG, and U.K. agreed to test and evaluate the tank guns each nation's army then preferred in hopes of selecting one as standard. These tests, which became known as the Tripartite Gun Trials, were scheduled for early 1975, and were to compare the U.S. Army's 105mm rifled gun with the improved ammunition being developed for it against the British 110mm rifled gun and the 120mm smoothbore gun with caseless ammunition then being developed for the Leopard II.[29]

Although the MOU committed no one to buying the winning competitor, the U.S. suggested that it would mount the winner in its XM-1. As Schlesinger asserted in his FY1976 posture statement,

> The XM-1 prototype will mount the current 105mm gun, but the main gun for the production model will be determined after the shoot off evaluation of other U.S., U.K., and German gun and ammunition systems.[30]

The trials in fact were timed to mesh with the XM-1's development schedule; evaluation results were to be published in August 1975, leaving time for the U.S. Army to take them into consideration in writing the XM-1 full-scale development RFP due for publication in October of that year.[31]

In December 1974 Germany and the United States concluded a second MOU that went beyond tank guns to the much broader range of possibilities broached in Schlesinger's letter of September 1973. The U.K. played virtually no role in this and subsequent efforts to collaborate largely because the development schedules of the XM-1 and the Leopard II were fairly closely aligned, with the German tank due to enter production in 1978, while XM-1 production was scheduled to begin at a low rate in that year and move to full capacity in 1981. By contrast, the U.K.'s Chieftain development project was "about half a generation off" the U.S.-German schedule.[32] In addition, between them the U.S. and the FRG field the major share of NATO's tank forces. Hence, standardization of U.S. and German tanks was seen to offer NATO the greatest tactical and logistical gains.[33]

In this bilateral MOU the two nations agreed, first, to make "all reasonable efforts to achieve maximum standardization" of the Leopard II and the XM-1 tanks.[34] At the time, this created nothing more than an information exchange between the two armies with the possibility that each might incorporate one or more of the other nation's tank components into its own tank design. The MOU committed neither nation to purchases of specific components.

Second, the December 1974 MOU sought to create the possibility for what Schlesinger had called in his September 1973 letter "a final evaluation that one of the tanks could meet the needs of both . . . armies." Although this wording suggests that Schlesinger considered either tank a likely candidate for standardization, the Germans did not. As OSD's Director of European and NATO Affairs put it two years later,

> When they [the Germans] came to us to sign the MOU [of December 1974], they said, we are way ahead of you, you have been held up for one reason or another, and we have produced all these [Leopard II] prototypes, we have our factories ready to go, so we are going to offer you our tank, and you can look at it and if you like it, we have standardization.
>
> They did not say, we are going to buy your tank. There was no U.S. tank at that time . . . they are ahead of us.[35]

Hence, the December 1974 MOU--and subsequent negotiations as well--focused on testing the Leopard II in the United States for possible purchase by the U.S. Army. There was no commitment on the FRG's part to consider purchase of the XM-1.[36]

The XM-1 Program and the Bilateral Agreement

It was around the bilateral MOU that the first signs of tension between these steps toward collaboration and the XM-1's schedule first arose. For the Leopard II could not be tested in its then current form; the U.S. Army had examined that tank in 1972, after all, and found it short on armor, overly complex, and, by estimate,

too expensive.[37] Although the Germans were willing to redesign the tank in accordance with U.S. dictates, and indeed set about developing a "Leopard IIAV (Austere Version)" soon after the MOU was signed, they held out little hope that the redesign could be completed before September 1976, a date that fell *after* the U.S. Army had scheduled tests for its XM-1 prototypes.[38] German negotiators thus asked that the XM-1 program be slowed sufficiently to allow for side-by-side testing of all prototypes. U.S. negotiators, however, were unwilling to make changes in the XM-1's original schedule.[39] As it happened, neither the U.S. Army nor the Congress proved willing to alter that schedule to accommodate the FRG position.

The U.S. Army wrote its position on the issue into the December 1974 MOU itself, which stated only that the Leopard IIAV would be delivered to the U.S. Army by September 1, 1976, "for comparative test and evaluation."[40] By this the service understood that tests of the XM-1 prototypes would take place as originally planned. The two countries further agreed to fund jointly a study to determine the German tank's production costs.[41] The results of this study were to take the form of a bid on the XM-1 full-scale development RFP that then could be compared to the bids submitted by the U.S. competitors. Significantly, in the MOU the U.S. made no explicit commitment to buy the German tank *even if* it outperformed the XM-1 prototypes. Nonetheless, later pronouncements by the Secretary of Defense indicated that the final results of the Leopard evaluation would be available by March 1977, and would be "considered fully in the process of decisionmaking on tank procurement."[42]

The Congress made clear *its* position on the scheduling issue the next year when the Army submitted its budget proposal for FY1976 and the transition period of July to September 1976 (to account for the rescheduling of the fiscal year--referred to hereafter as FY197T). The proposal included a request for funds necessary to begin full-scale development of the winning XM-1 candidate, a clear signal that the service intended not only to test its tank prototypes but also to continue the entire XM-1 program as originally scheduled.[43]

Reactions in the Congress to the Army's proposal varied with almost each committee in which it was considered. The House Armed Services Committee, which had been so instrumental in shaping the XM-1 program in 1972, approved the request without comment.[44] By contrast, the Senate Armed Services Committee deleted funds for full-scale development work on the tank and suggested that the Army continue the dual prototyping effort until *after* the Leopard had been evaluated.[45] The House Appropriations Committee recommended that the Army select a contractor as scheduled, but delay full-scale development until after the Leopard's evaluation.[46] Finally, the Senate Appropriations Committee took the same position as the House Armed Services Committee, recommending that "the XM-1 tank program is to be in no way hindered by the evaluation of the Leopard II tank."[47] Significantly, however, the conference reports from each set of House and Senate committees fully approved the Army's budget request.[48] The Congress as a whole thus expressed its continuing commitment to seeing the XM-1 program proceed as originally scheduled.

The XM-1 Program and the Trilateral Gun Trials

By the time the Congress had declared its interest in seeing the XM-1 program move along on schedule, the Tripartite Gun Trials had been held and the results had been published. In the long run these tests helped shape attitudes in the United States toward the long-term prospects for standardization, and thus had a direct bearing on the positive steps taken in 1976 to achieve some degree of commonality between German and U.S. tanks. The debate those steps provoked, however, cannot be fully understood without examining the short-run reaction of both OSD and the service to the effect the Trial results were supposed to have on the XM-1 program. As with the bilateral MOU, here again the results of the Trilateral Gun Trials were not permitted to upset the ongoing XM-1 program.

The Trials themselves took place over the winter and spring of 1975, and the results were published in August of that year. Observers from all three nations agreed that the U.S. 105mm gun with its improved ammunition provided more than enough power to meet the existing threat.

They also agreed that 120mm guns seemed best suited for meeting the longer-term threat.[49] And because the FRG had fielded the only 120mm gun in the Trials, its candidate seemed the best choice available.[50]

Notwithstanding these conclusions, gun programs in each of the three participating nations continued as they had before. The U.K. decided to move ahead with a 120mm *rifled* gun of its own design while the Germans felt justified in continuing the development of their 120mm smoothbore with the idea of employing it on the Leopard II. Meanwhile, Secretary of the Army Martin Hoffman announced that for the U.S. Army

> the evaluation clearly substantiated that continuation at this time with the 105mm system, which had demonstrated adequacy to defeat the current and mid-term projected threat, best meets the desired objective of standardization of the NATO tank fleet.[51]

Hoffman's comment signalled that for the short term, at any rate, production models of the XM-1 would be equipped with the 105mm gun, as the service originally had planned.

The Trials produced general agreement in the Defense Department that at some future point a 120mm gun of some design would be added to the XM-1. Despite the test results, however, U.S. armor experts were not convinced that the German gun was best suited for this role. On the one hand, these experts had technical reservations about the German system, which was still being developed.[52] On the other hand, members of the Army's armor community, like their British counterparts, generally preferred rifled to smoothbore guns because rifled guns could fire more types of ammunition and hence appeared to offer greater flexibility.[53] Thus while the Tripartite Gun Trials served to reaffirm the Army's wisdom in selecting the 105mm gun as its original choice for the XM-1 main armament, they produced in the Army a "wait and see" attitude toward the idea of fielding some kind of 120mm gun in the future.

In any case, to have taken major steps to permit the later incorporation of a 120mm gun in the XM-1 by designing a "dual-turret"

capable of accepting both 105mm and 120mm guns would have involved "a complete turret redesign" from the service's point of view. And this, the project manager indicated, would have entailed a "1-year schedule slip, and about $44 million cost increase in R.D.T.&E. funds."[54] From the service's perspective, in other words, any attempt to integrate the Trial results into the XM-1 program at that time would have violated Congressionally approved cost and schedule constraints on the program.

The service thus made no major changes in the XM-1 program as a result of the trials, despite the indication that, in the long-term, a 120mm gun would be preferable to the 105mm gun then destined to be the XM-1's main armament. To be sure, the service discussed dual turret options with its contractors, and "made some rather rough estimates of what the (dual turret) cost might be."[55] Both contractors apparently changed some components in their turret designs to make them compatible with a variety of main guns.[56] But the full-scale development RFP for the XM-1 made no specific demand for changes in the designs the XM-1 contractors had begun developing in 1973.

Significantly, members of OSD held a slightly different view of the results of the Trilateral Gun Trials and their effect on the XM-1 program. These individuals saw the Trial results as grounds for a component exchange with either the U.K. or the FRG, notably one involving U.S. acceptance of either nation's 120mm gun in return for European acceptance of one of the engines being used to power the XM-1 prototypes, most probably the turbine engine Chrysler had chosen as its powerpack. Moreover, they proceeded under the impression that

> the Army was pursuing the XM-1 development program, including the contractor competition phase begun with the publication of the Request for Proposal in October, 1975, with sufficient flexibility to permit the two competitive tanks to be compared with either power plant or with either gun (or, more precisely, with a turret that would accept either [the 105mm or the 120mm] gun).[57]

That such is not the case would not become clear until the middle of 1976, after more specific collaborative agreements had been concluded with the U.K. and, especially, the FRG.

COLLABORATION DELAYED: AGREEMENT AND DEBATE, 1976

In July of 1976 the U.S. and the FRG concluded an addendum to their 1974 MOU that committed them to an exchange of tank components in the event that the U.S. Army failed to purchase the Leopard IIAV. In an effort to prepare the XM-1 prototypes for the incorporation of German components as early as possible, the Secretary of Defense ordered the first real change in the XM-1 program's original schedule, lengthening the development slightly to allow time for contractors to add standardization features to their prototypes. His action provoked not only a heated reaction from the House Armed Services Committee, but also specific actions aimed at lessening the addendum's effect on the XM-1 program's original cost and schedule goals. With these steps the committee continued its effort, begun in 1975, to separate the collaborative process from the XM-1 program sufficiently to allow the XM-1's development to proceed at its original pace.

Secretary of Defense Donald Rumsfeld initiated the negotiations leading to the addendum by sending a U.S. team to meet the FRG in Brussels in June 1976. The Secretary sought the tactical and logistical benefits of standardization. Because those benefits could be achieved more cheaply while the tanks were still being developed rather than through retrofits applied after production had begun, Rumsfeld was anxious to achieve some degree of standardization soon. Thus he "specifically directed, as a minimum, . . . [that the team devise] a plan for a common engine and a common main gun,"[58] meaning an exchange of the U.S. turbine engine for the FRG's 120mm gun.

This was not the only team of U.S. negotiators sent to Europe in this period as part of the nation's effort to enhance the prospects for tank standardization within the alliance. While one team of negotiators traveled to Germany, an associated group arrived in the U.K. to discuss that nation's 120mm rifled tank gun project.[59] A multi-stage effort, this one involved the development of a new family of

120mm ammunition and the later development of a new, specially-processed 120mm gun. Though work on the British system remained in its early stages, the U.S. Army was anxious to follow the gun's development.

Both U.S. teams negotiated agreements. On July 14, 1976, the U.S. and the U.K. concluded a Letter of Agreement (LOA) committing the two nations to tests of the U.K.'s new ammunition at the U.S. Army's Aberdeen Proving Grounds in December 1976.[60] Meanwhile, in the FRG negotiators worked out the addendum to the December 1974 U.S.-German MOU. Though dated July 28, 1976, the addendum was available in draft form late in June. Because it made specific commitments to exchange components, it was and remains the more important of the two agreements.

The addendum began by leaving room for the possibility that U.S. purchase of the Leopard IIAV might obviate the need for a component exchange. The German tank was still due to be tested in the U.S. starting in September 1976, and there remained a chance that the U.S. Army might select it over the XM-1 prototypes. The addendum thus prescribed that the Leopard tests would "continue in keeping with the [December 1974] MOU."[61]

It then turned to the specific tank components that the two nations would exchange if the U.S. Army decided to continue developing the XM-1. Focusing first on the subject of tank guns, U.S. negotiators saw to it that the addendum's wording left room for standardization of either the German or the British gun. The U.S. agreed to "immediately initiate development of a turret design(s) for the XM-1 which is compatible with both the 105mm and the smoothbore and rifled bore 120mm guns."[62] The FRG agreed to "observe the U.S. testing of the U.K. gun and ammunition and . . . continue investigations of changes required to mount the rifled gun in the Leopard II turret."[63]

The addendum then went on to outline the course of decisionmaking on main gun standardization: "The FRG and the U.S. and, hopefully, the U.K. and other NATO nations," it asserted

> will agree by 15 January [1977] upon a 120mm configuration (smoothbore or improved rifled), meeting both the XM-1 and Leopard II requirements and suitable for introduction into production by March 1977.[64]

As part of the data exchange underlying this process, the Germans agreed to supply the U.S. with the details of their main tank gun design. They also agreed that following the U.S. Army's tests of the Leopard IIAV the tank would be "modified and tested with a smoothbore 120mm gun."[65] This meant that the Army would test both the German and British 120mm guns at about the same time, giving the service a comparative basis on which to make its gun decision in January 1977.

The addendum then focused on the U.S. turbine engine, which U.S. negotiators agreed would be "incorporated into the XM-1 at the earliest practicable date."[66] The FRG agreed to

> initiate production and introduce the standardized turbine power package into the Leopard II at such time as it has met the requirements for entry into production, the U.S. has certified it as it has met the requirements for entry into production, the U.S. has in fact incorporated it into the XM-1 production and has certified it as complying with the specified unique FRG requirements . . . [which] will be delivered to the [Department of the Army] by 15 January 1977.[67]

Although the addendum made no mention of precisely *when* the gun and engine exchange would be completed, the addendum's wording left the clear impression that it would occur early in the production cycle if not its very start:

> During the period leading up to the certification for production of the turbine power package and the 120mm gun, both countries will be able to proceed with the development and test and, *if necessary*, first-lot production of their current design Leopard II and XM-1. . . (emphasis added).[68]

Other items mentioned as part of the exchange included tank tracks and associated hardware, the U.S. night vision device, the FRG gunner's telescope, and fasteners, which the U.S. agreed would be metric on both tanks, allowing tool kits to be standardized as well. The two nations also agreed to consider standardizing fire control systems after the Leopard IIAV had been tested at Aberdeen Proving Grounds. The agreement thus produced the "minimum degree of commonality" shown in Table 4.

Table 4

MINIMUM DEGREE OF COMMONALITY
ESTABLISHED BY JULY 1976 ADDENDUM

SYSTEM	DEGREE OF COMMONALITY
Fuel	Common
Ammunition	Common
Gun	Common
Fire control	Functions common, hardware potentially common
Track (plus sprockets and related hardware)	Common
Engine	Common
Transmission	Common
Night vision device (FLIR)	Common
Gunner's telescope	Common
Critical fasteners suspension	Common types separate
Hull and turret metal parts	Common technology but different designs

SOURCE: Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform Hearings*, 94th Cong., 2d Sess., Part 3, p. 37.

Although the addendum promised to standardize a variety of tank components, it was the tank gun-engine exchange that became the object of debate soon after the addendum was signed. For as the addendum was being negotiated the XM-1 program office was engaged in determining the winner of its tank competition; it had planned all along to announce source selection at the end of July, 1976. While being briefed on the results of the source selection process, however, Deputy Secretary of Defense William Clements discovered that the competition had produced no dual-turret or interchangeable engine options, as called for in the addendum.[69] Members of the Army's source selection board argued that such options could be designed and fabricated by the winning contractor during the next phase of the XM-1 program.[70] Clements, however, felt that the XM-1 competition should be extended long enough to allow the redesign of turrets and engine compartments to take place in a competitive environment. Thus on July 22, 1976 the Defense Department announced a delay of up to 120 days in the XM-1 source selection process to allow the XM-1 contractors time to redo their bids.

This represented the first real change in the XM-1 program's schedule since the program had begun four years earlier. The move provoked an inquiry by members of the House Armed Services Committee, which had consistently sought to keep the program on schedule. In September 1976 two members of that committee, Samuel Stratton (D-N.Y.) and Elwood Hillis (R-Indiana) were named to a special "XM-1 Tank Panel." After hearings, Stratton and Hillis reported to their committee in a manner highly critical of the addendum.[71]

Because the component exchange, and especially the gun exchange, moved the XM-1 program from one "of low technical risk to one of unknown technical risk,"[72] neither Congressman fully believed that the announced program delay of 120 days would be the addendum's only effect on the tank program. Their report noted that "the project manager, the most authoritative witness on the subject, indicated that in addition to the already announced delay of four months, an additional six months was an optimistic estimate."[73] It also noted the project manager's opinion that

> the increased costs that will result from the delay in the program would be between $800 million and $943 million. No acceptable challenge to those cost estimates was received.[74]

Although the Secretary of Defense had written that "any additional program cost would be related to enhanced capability,"[75] the Tank Panel came to the opposite conclusion. On the other hand, Hillis and Stratton argued that these changes in the program delayed the introduction of an urgently needed weapon. They agreed that there was "a critical need for a new Army tank," and further noted that the "leadership of the Army concurred that a year's delay in obtaining a new tank would be unacceptable."[76] On the other hand, they did not feel that the program changes promised commensurate improvements in the XM-1. Indeed, they charged that the tank gun exchange might result in a "degradation in combat capability. . . .," stemming both from the delayed introduction of the XM-1 and the fact that because the 120mm gun could fire only two kinds of ammunition, it could not "perform important missions performed by the 105mm gun."[77]

On the issue of the military value of a 120mm gun, Stratton and Hillis went on to note that the addendum was in their view "written in such a way as to exclude the British rifled-bore 120mm gun and make the German smoothbore the only choice."[78] In fact, the British Minister of Defense had already made this point in public, arguing that, because the British gun could not possibly be ready for production by March 1977, the addendum's wording effectively eliminated the U.K. from competing for the U.S. market.[79] On this point, the XM-1 Tank Panel echoed the U.K.'s complaints as well as the U.S. Army's interest in that nation's rifled gun.

Finally, the two Congressmen argued that the tank-gun decision "was unanimously opposed by the civilian and military leadership of the Army."[80] They also suggested that standardization was being pursued for its own sake, with no thought for "enhanced capability for the tank. . . ."[81] And, finally, they noted that the Defense Department had not consulted with the Congress:

> Congress clearly provided in the conference report on the fiscal year 1976 Defense authorization bill direction that the XM-1 program was to go forward on schedule . . . In changing the program, the Defense Department violated the terms of Congressional approval; and in the opinion of the panel, the action it took is improper without Congressional authorization of the reprogramming funds.[82]

Behind this criticism lay the fundamental premise that standardization should not be allowed to disrupt the XM-1 program. Hillis and Stratton left no doubt about their view of the XM-1 program's objectives:

> . . . the overriding objective of the XM-1 program . . . is to field the most cost-effective main battle tank at the earliest date. . . . [This objective] must take precedence over secondary objectives such as standardization or interchangeability of components. . . .[83]

Standardization in their view should have been applied elsewhere:

> The panel wishes to make it very clear that it does not oppose standardization. . . . The panel believes there are many smaller items of equipment where the NATO forces could standardize and achieve cost savings and increased cost-effectiveness. The question is whether standardization should be accepted when it results in delay, increased cost, increased technical risk and loss of combat capability.
>
> In the panel's opinion, the answer is no.[84]

Most of these conclusions were formally endorsed by the full House Armed Services Committee. The "Hillis Resolution," as it was called, was approved by the full Armed Services Committee on September 28, 1976. The resolution threatened funding for the gun exchange with the following language:

> The commitment to agree with the FRG on a specific 120mm gun configuration by January 15, 1976 [sic] was not justified to the Committee on the basis of known military requirements. Therefore, *the Committee cannot support or fund any such commitment until:* (a) Alternative 120mm

> gun systems have been comprehensively tested and evaluated by the Army; and (b) One of those alternative 120mm gun systems has clearly demonstrated superior combat effectiveness over the present 105mm gun and its future improved ammunition.[85]

The resolution also asserted that the 120mm gun tests should be conducted "as a parallel program, separate and apart from the funding of the XM-1 program."[86]

Despite support for the collaboration elsewhere in the Congress,[87] the Hillis Resolution became Public Law as part of the FY1978 Defense Appropriation Authorization Act.[88] Thus, the Resolution produced its intended effect: On January 12, 1977, the Defense Department announced the completion of an "addition" to the addendum to the 1974 MOU in which the FRG recognized the U.S. Army's need for further tank gun testing and agreed to await the Army's final decision on or before December 30, 1977, rather than January 19, 1977.[89] In the intervening year the service would test both the U.K. and FRG 120mm guns.

To be sure, the July addendum basically remained intact. The 120-day program delay ended on schedule, and in November 1976 the Army awarded Chrysler Corporation the XM-1 full-scale engineering development contract. The gun that ultimately would go into that tank would not be selected for another year, however, and this alone placed its incorporation into the tank well past the time suggested in the original addendum. The addition to that addendum thus represented a compromise between those wishing to see the XM-1 program move along as originally planned and those wishing to introduce into it a degree of collaboration.

COLLABORATION REJECTED: THE LEOPARD IIAV TRIALS

Despite the attention given the component exchange over the summer and fall of 1976, collaboration ran on two tracks throughout the period; there remained the possibility that the U.S. Army would buy the Leopard IIAV outright, making irrelevant most of the 1976 Addendum. Indeed, the Army's tests of the German tank began just as the XM-1 Tank Panel began debating the wisdom of exchanging tank

components. Only after those tests had been completed and the Leopard rejected did collaboration become solely a matter of the component exchange.

In accordance with the 1974 MOU in September 1976, the Federal Republic delivered three test copies of its Leopard IIAV to the U.S. Army; a fully equipped prototype, a partially-completed but test-worthy mobility test rig, and a fully armored turret and hull for ballistics (vulnerability) tests. The tests ran through December, at which point the FRG withdrew its tank from competition. Although no specific reason was given for the withdrawal, Major General Baer later stated that the Leopard simply did not meet U.S. requirements.[90]

> (I)n a general sense . . . the Leopard is a very good tank; however, against the specific U.S. requirements, against which we were making this judgment, . . . it falls short in several areas which are of major concern to us, . . . principally in the area of survivability.[91]

General Baer's statement echoed those made in Germany eight years previously, when the FRG rejected the MTB-70 for its failure to meet the Bundeswehr's requirements. Pursuit of the goal of providing one tank for two armies once again had foundered on the divergent needs of each military service.

On January 12, 1977, in the same addition to the Addendum that delayed the Army's tank gun decision for a year, the two nations agreed to focus strictly on the component exchange portion of the 1974 MOU. The July 1976 Addendum and the addition to it thus became the key agreements governing the collaborative process. Although that process once again would become the object of debate, it ultimately would prove to be realistic enough to promise some degree of "harmonization" between U.S. and German tanks.

COLLABORATION RENEWED: COMPLETING THE COMPONENT EXCHANGE

The U.S. Army evaluated the British and German 120mm guns and the U.S. 105 in 1977, and in January 1978 Secretary of the Army Clifford L. Alexander named Germany's gun the winner. The FRG's smoothbore

120mm gun would be mounted on production versions of the XM-1 tank as soon as the gun was ready for domestic (U.S.) production; probably, he announced, sometime in 1984. About 3100 105mm XM-1s would be produced; the remaining 3950 tanks of the total buy of 7000+ XM-1s would carry the German 120mm gun.

In the meantime the gun and tank programs were to remain separate; the XM-1 would enter production as scheduled, armed with 105mm gun, while the 120mm gun would enter a six-year (minimum based on a "success oriented" development schedule), $171.5 million "cooperative development program" that would complete the gun's development, prepare it for production and ensure its smooth integration into the XM-1's dual turret. The details of the proposed agreement with the FRG were codified in a set of "joint minutes," an "agreement to agree" negotiated by members of the Army Secretariat and the German Ministry of Defense.[92]

In answer to the dual questions of why the 120mm gun in general and why the German smoothbore gun in particular, Alexander gave the following explanation:

> First, while we are confident of the ability of the 105 with our improved ammunition to meet current and near-term requirements, for the longer term the inherently superior power of the larger gun will provide a significant advantage against more advanced armors. Second, long-range tank weapon commonality within NATO is increased by U.S. adoption of the German rather than the British gun. This is primarily because of the larger German tank fleet and the lack of complete interoperability between the fielded Chieftain tank gun and the new British weapon. The German and the British guns are basically similar in performance and potential.[93]

Although Secretary Alexander denied that his decision had been influenced by Germany's consideration of the AWACS buy, within OSD the "symbolic significance to the Germans" of the tank gun decision apparently played a minor role in precipitating support for the decision.[94]

Congress and Collaboration, 1978

In accordance with the DoD Appropriation Authorization Act of 1978 (the Hillis Resolution) Secretary Alexander's decision on the gun issue went before the Congress for approval soon after it was made. Actual debate on the issue focused on an Army reprogramming bid that followed soon after, in which the service sought to funnel $10.1 million of its FY1978 funds into the tank gun's development. As with all major DoD reprogramming actions, this one required approval of the Appropriations and Armed Services Committees of both houses of the Congress. Although it received relatively strong support in the Senate, in both committees of the House it was less well received.

The Investigations Subcommittee of the House Armed Services Committee, under the leadership of Samuel Stratton, took up the reprogramming bill in April 1978. As he had in 1976, Stratton criticized the gun decision for its lack of a sound military rationale. He based his criticism largely on the testimony of Brigadier General Philip L. Bolte, head of the Army team that conducted the 1977 gun trials. Bolte found the switch from 105mm to 120mm unjustified because, as he told members of the subcommittee,

> If [the Soviets] can build a tank that will stop a 105mm [round], for a nickel more [they] can probably stop the 120mm.[95]

In Bolte's opinion, it was not worth the risk and expense of adding the 120mm gun to hedge against the possibility that the Soviets might build a tank with armor that fell *between* the capabilities of a 105mm and a 120mm gun.[96]

Secretary of the Army Alexander and his Assistant Secretary for R&D, Dr. Percy Pierre, put forward two arguments in defense of the 120mm gun's military worth. First, because of its larger size, the 120mm gun would always offer more power than a 105mm gun; any improvements in the 105mm round could ultimately be added to the 120mm round. Dr. Pierre placed the usable power differential between the two guns at about 10 to 15 percent. This in itself was important, Dr. Pierre argued:

> . . . if you're ever in a situation where you couldn't penetrate with the 105mm or 120mm, you'd certainly prefer to have that 120mm on your tank . . . because you can penetrate at other places, that is, the [enemy] tank is not equally protected all around.[97]

The second argument stemmed from the premise that armor remained a highly uncertain technology, one in which the possibility for radical improvements could not be easily discounted. Under these conditions, it made sense to accept the higher-powered gun simply as a hedge against these uncertainties.[98]

Stratton and other members of the subcommittee remained unconvinced; in their report they noted that there existed "no convincing evidence that the decision was based on military requirements."[99] Because the XM-1 would be able to carry fewer of the larger 120mm rounds than the 105mm rounds, the 120mm gun might actually "reduce rather than enhance the combat effectiveness of the XM-1." Thus in their view, the gun decision was a "nonmilitary choice."[100] In addition, in its haste to ready the new gun for production the Defense Department was likely to deploy it with a cartridge less effective than the sophisticated round the Army had developed for the 105mm gun.[101] Finally, members of the subcommittee worried that the money to pay for the German gun's development would come from other Army programs.[102]

Most important, Mr. Stratton specifically criticized the coproduction arrangements covering the gun's production in the United States. As they stood at the time, the "joint minutes" prohibited the United States from exporting XM-1s with U.S.-built 120mm guns mounted on them. In Stratton's view, this meant in practical terms that NATO countries would "find it simpler and cheaper to buy the Leopard II with the German-built 120mm gun rather than purchasing our tank." Or, as another member of the Investigations Subcommittee put it, "the net effect of this [agreement] will be virtually defaulting the NATO tank market to West Germany."[103]

Behind these criticisms and concerns lay the same differences over the value of collaboration on main battle tanks that had surfaced

in the XM-1 Tank Panel's report of September 1976. At that time, the professed goal of collaboration with the FRG was standardization, and the Tank Panel denied that standardization was worth the "delay, increased cost, increased technical risk, and loss of combat capability,"[104] that in this particular case seemed to go with it. By 1978 the "two-way street" or "political solidarity in the alliance" had become another important component behind U.S. interest in collaboration, and Stratton questioned the value of this as well. Referring to the estimated life-cycle cost of adding the 120mm gun to the XM-1, Stratton stated:

> I can understand the political implications, but again, I don't know whether it's worth $1.2 billion or more for those.[105]

Although OSD's reasons for collaborating with the FRG may have been changing, Stratton's view, and the view of the House Armed Services Committee, remained consistent; both preferred spending money on getting as many XM-1s into the field as soon as possible.

Notwithstanding the subcommittee's criticism, concerns and differences with the DoD concerning the real value of the collaborative process, Stratton and his associates shied away from simply blocking funds for the gun's development. In a letter dated May 26, 1978, Committee Chairman Melvin Price notified the Secretary of Defense that the Committee's approval of future funding for the 120mm gun's development and production would be contingent upon "implementation of XM-1 production in accordance with the schedule endorsed by OSD to field 7,058 XM-1 tanks by 1987," and that "XM-1 production with the 105mm gun must not be slowed or delayed because of a separate, parallel program to develop the 120mm gun."[106] The letter also stated that the Committee would approve no funding for the gun's development until the Army and OSD demonstrated the extent to which the program was being funded "in addition to rather than at the expense of other Army programs previously approved."[107] Finally, Price expressed the Committee's desire to see the final licensing agreement with the FRG, and its belief that "there should be no provisions in

the licensing agreement which would restrict the ability of the U.S. to sell or co-produce a complete XM-1 tank and gun to any NATO country."[108]

Significantly, whereas the Hillis Resolution had flatly delayed the gun decision for a year, Price's letter assured funding for the 120mm gun's development so long as the conditions stated in it were met. As it happened, most of these conditions had already been met, while the precise terms of the licensing agreement were soon to be negotiated with the FRG. Thus the Committee approved the Army's reprogramming bid, as well as its request for FY1980 funding for the 120mm gun's development.[109]

Members of the House Appropriations Committee took a rather different line of criticism than that of their compatriots on the Armed Services Committee. Members of the Appropriations Committee were "convinced that the FRG 120mm gun [was] needed for our new XM-1 tank as soon as possible." But they quarreled with the seemingly high cost of the six-year development program. Of the $171 million projected for that development effort, the Army wanted $84 million to develop the gun itself, and $87 million to prepare the XM-1 turret for its acceptance. Members of the committee argued that, according to the 1976 Addendum, the *FRG* should be carrying most of the gun's development costs, while the design of dual turrets was supposed to have been taken care of during the four-month period from July to November 1976. The Committee thus denied the Army's reprogramming bid, arguing that the FRG should accept more of the gun's development costs while the Army should reduce the costs of integrating the gun into the XM-1.[110]

At the Army's request, the Appropriations Committee Subcommittee on the DoD agreed to give the service another chance to justify these costs. In September 1978 the Under Secretary of Defense for Research and Engineering joined members of the service and the Army Secretariat in addressing members of the subcommittee. Money for the gun's further development, they argued, would go toward redesigning its breech (in order to lower production costs) and developing new ammunition.[111] As for the turret, although in 1976 both XM-1 contractors

had enlarged their original turret designs to accept both guns, the inside of the turret needed to be reconfigured to "optimize" it for the 120mm gun's installation and use: the recoil mechanism had to be redesigned, for example, as did the ammunition racks.[112] Although the service had pared about $6 million from the cost of further developing the gun, the inflation associated with program delay would soon eliminate those savings. Based on this more elaborate justification of the costs of its gun program, the House Appropriations Committee approved the reprogramming request.

Thus in September 1978 the tank gun decision finally received the support it required of the Congress, support it had not received two years earlier. The change in Congressional attitudes was due largely to the nature of Secretary Alexander's decision, which for the first time made U.S.-West German collaboration compatible with an uninterrupted XM-1 program. This tended to build support within the Army, and the appearance of the Army Chief of Staff himself in the Congress to testify in favor of the gun decision no doubt helped generate support for the decision there.

But Alexander's decision also had a direct effect on Congressional critics. In 1976 Representative Stratton had spoken for many of his colleagues in voicing fear that collaboration would raise the cost and stretch the schedule of the XM-1. He was speaking, after all, just after the Secretary of Defense had delayed source selection from July to November 1976. By 1978, however, it was possible to see the effects of collaboration on the XM-1 program more clearly. The tank's unit cost estimate as well as its total development cost estimate remained below the program's original estimate (see Table 5). And although the four month schedule slippage introduced in the summer of 1976 had set the program behind the Army's original development schedule by four or five months, it had not produced a series of more serious delays in the months since (see Table 6). (The XM-1 development was delayed in 1979, but not as a result of collaboration. Rather, the apparent unreliability of the tank's turbine engine necessitated further testing before full production could begin.) Thus, the central concern of the Congress to see the XM-program move along

Table 5

XM-1 COST ESTIMATES, 1973 AND 1978

Cost \ Date of Estimate	1973	1978 (31 March)
Unit Cost ($72)	530,400[a]	526,000[b]
Development Cost ($72)	422.6M	419.6M[c]
Procurement Cost ($72)	$1970.2M	$3717.0M[d]

SOURCE: "XM-1 Selected Acquisition Report," 31 March 1978, pp. 9-10.

[a]Rollaway cost per unit for 3,312 tanks @ 30/month, all tanks armed with 105mm gun. Includes cost of government furnished equipment and additional hardware (machine guns, radios) that was not included in the Army's 1972 DTC goal of $507,000.

[b]Rollaway unit cost for 7,058 tanks @ 90/month, 2441 tanks armed with 105mm gun, 4617 tanks armed with 120mm gun.

[c]Does not include cost of 120mm gun development program.

[d]Includes costs associated with increased total buy from 3,312 to 7,058 tanks.

Table 6

XM-1 PROGRAM SCHEDULE

Event	Initial Estimate	As of March 1978
DSARC I	January 1973	January 1973
DSARC II/Source Selection	July 1976	November 1976
Development/Operational Tests II begin	August 1977	February 1978
end	June 1979	July 1979[a]
Low Rate Initial Production	August 1979	May 1979[a]
Full Production Decision	August 1980	February 1981[a]

SOURCES: Table 3 (p. 35) and "XM-1 Selected Acquisition Report," March 1978, p. 7.

[a]Estimates as of 31 March 1978.

as originally scheduled and within original cost projections for the most part had been satisifed.

Renegotiating the Gun Agreement

With the House Appropriations Committee's approval of its reprogramming bill and FY1979 funds coming to it as the new fiscal year began, the Army was in a position in fall 1978 finally to work on the 120mm gun development program. It did not do so, however, because the "joint minutes" needed renegotiation, as had become clear with the House Armed Services Committee's criticism of its export provisions. In fact, U.S.-German discussions aimed at shoring up flaws in the "joint minutes" had begun before fall 1978, but had produced no firm result. With no firm contract and hence no technical data on the German gun, the service chose to delay funding for the gun development program.

Perhaps the underlying problems here lay in the bids that accompanied British and German 120mm guns submitted to the United States for tests in 1977. Both nations had been asked to submit to the U.S. Army sealed bids on production rights to their guns. In fact, each submitted a proposal too general to serve as the basis for a firm contract. The service thus chose the German gun, and only then turned to the task of negotiating (in a sole-source environment) a contract with the FRG. The negotiations had produced the joint minutes, but on key points--especially the question of export rights--hard negotiating produced fuzzy language that permitted observers in the United States and the Federal Republic of Germany to see the agreement in different lights.[113]

Not until March 1979 was agreement finally reached on the gun license contract. The FRG agreed to allow the U.S. to export XM-1s armed with its 120mm gun as soon as that tank/gun system was in production in the United States. In return, the U.S. gave the FRG a larger license fee and agreed to pay the fee in two lump sums in lieu of royalties. With a satisfactory agreement in hand, the United States Army began work on the 120mm gun development program.[114]

The delay of nearly a year in starting this program raised its cost in escalated dollars from $171.5 million to $181 million. The increase, due solely to inflation, negated whatever savings the Army had been able to achieve by paring the original proposal. Significantly, however, the program completion date remained set for August 1984, as originally set in January 1978, making the gun development program more "success-oriented" than ever.[115]

Should unforeseen complications lengthen the program and raise its cost still further, it may become the object of Congressional debate once again. But debate about the gun development program probably will be separate from debate about the tank itself. Indeed, the XM-1 program has had its share of problems since 1978, notably those associated with seeming unreliability of the tank's turbine engine. But debate on this issue has had nothing to do with collaboration. Collaboration and the tank program now are running in separate tracks that will not converge until 1984 at the earliest. As it was before 1976, that program once again is free to move at its own pace.

The Prospects for Expanded Collaboration

As it was when Secretary Alexander first announced the gun decision early in 1978, U.S. purchase of the FRG's 120mm gun remains virtually the only element of collaboration linking the XM-1 and Leopard II programs. The Leopard's Forward Looking Infra-Red (FLIR) night-vision system will contain some common U.S. components, and the two tanks may have interchangeable, if not identical tracks.[116] Beyond that, however, the tanks will be what they were set up to be when each development program was initiated: products of national development programs designed to respond to the requirements of national military services.

The status of the U.S. turbine engine is instructive. Although the 1976 Addendum committed the FRG to buying the turbine if and when it met the Bundeswehr's requirements, one of those requirements set a standard of fuel consumption more appropriate to a diesel than to the relatively thirsty turbine engine. Thus the FRG has ruled against the turbine on much the same grounds that led the U.S. to rule out

buying the Leopard IIAV: military requirements of the two nations cannot be bent sufficiently to allow for common components.[117]

Although contractors and military personnel in both countries continue to work to expand collaboration between the two tank programs, at this point they seem unable to overcome the momentum that has gathered behind the purely national elements of each program. Tank collaboration in this case seems likely to remain a matter of guns alone, unless other elements of the collaborative effort begin to receive the same attention and concern that has marked the 120mm gun deal.

CONCLUSION

Establishing collaboration across two national tank development programs has not been easy. What began in 1973 as an ambitious attempt either to buy a German tank for the U.S. Army or, failing that, to exchange components between the Leopard II and the XM-1 has dissolved into an agreement to mount a German tank gun on a portion of the XM-1 tanks to be produced over the next decade. Forging even this much collaboration has involved the close attention of high level defense officials in the U.S. and the FRG. And in the United States it has been a matter of considerable political debate.

At the international level, collaboration has been implemented successfully thus far only to the extent that it has received high level attention. Collaboration across these two tank programs began with conversations between the U.S. Secretary of Defense and his German counterpart. The agreements of 1974 and the key July 1976 Addendum were negotiated under explicit instructions from the U.S. Secretary of Defense. And the gun deal was largely the work of the Secretary of the Army, with occasional assistance from the Under Secretary of Defense. Such attention was essential to break the momentum that had gathered behind each national tank development program before the possibility for collaboration was broached, and to break the fix each nation's military service had on its own tank requirements. There has been nothing "natural" about this collaboration; the two governments involved have had to push hard to see it take root.

At the level of domestic U.S. politics, collaboration--and especially the 120mm gun deal--has been a political issue of some significance. After having cancelled the XM-803, the Congress made explicit its desire to see the XM-1 program proceed as rapidly as possible toward a unit cost goal that met with Congressional approval. After 1974, when the Defense Department concluded the first agreements that introduced collaboration into the XM-1 program, the Congress sought to minimize the effect of collaborative policies on the program's original goals, with the House Armed Services Committee taking the lead in this effort beginning in 1976. Although the basic thrust of the 1976 Addendum now has behind it a fairly strong political consensus, this should not obscure the rather heated controversy that enveloped the gun issue in 1976 and again in 1978.

There has been a close relationship between activities at the international and the U.S. domestic political levels. International negotiations did not begin until after each nation had begun developing its own tank, making it impossible to dovetail the two tank programs neatly into a collaborative process. This contributed to the perception that collaboration would add cost and time to the XM-1 program, and this in turn helped to make the program politically controversial in the United States. Conversely, domestic political negotiations in the United States clearly circumscribed OSD's ability to negotiate collaborative agreements with the FRG. For OSD, collaboration became a three-tiered process: negotiation of an initial U.S.-German agreement was followed by negotiations within the U.S. government over the specific form of the agreement, and this in turn gave rise to the U.S.-German renegotiation of the final agreement. Domestic political forces also made it more difficult for OSD to interest the U.S. Army in collaboration. Although genuinely interested in both British and German 120mm guns, many servicemen were reluctant to collaborate lest interference with the XM-1 program would endanger that program in the Congress.

U.S.-German collaboration as it now exists thus is a political *outcome*, shaped by no single hand but rather the fortuitous product of negotiations at two levels and their interaction. This is not

surprising: international negotiations virtually always involve compromise. And virtually all U.S. weapon development projects are the subject of compromise, both among elements of the Executive Branch, and between the Executive and Legislative branches of the government. To be sure, the XM-1 may have been the subject of especially heated debate in the United States, given that it was a program in which the Congress--and Representative Stratton, in particular--took a special interest from the start. But while collaboration may not be debated so vociferously in other cases, it seems likely that some debate will surround other collaborative efforts.

The existence of this domestic debate in the XM-1 case and its likelihood in other collaborative cases suggest two sets of lessons for Defense Department policymakers. First, insofar as Congressional debate over collaboration in the XM-1 case has been aired in terms applicable to collaboration on other systems, the Congress has presented DoD with guidelines it might usefully keep in mind in approaching collaboration in other weapon development projects. It has been argued, for example, that collaboration should not disrupt major weapon development programs by increasing their cost or stretching their schedule. Some Congressmen also have indicated their preference for collaboration only when it leads to demonstrable increases in the military effectiveness of the system being developed, demonstrable in this case being measured, in effect, by the extent to which uniformed servicemen favor the results of collaboration. Finally, other Congressmen have made it clear that collaboration on a specific system should in no way impede U.S. export of that system.

Second, if political debate is likely to be an expected part of the collaborative process, it enforces on policymakers a very different set of rules from those they have used thus far in pursuing collaboration. Insofar as the rationale for collaboration has been its military benefits and the possibility for savings that result from rationalizing production of systems and subsystems, policymakers face incentives to extend collaboration to as many systems as possible: more is better. But if the implementation of collaboration is going to involve political debate, *less* may be better. Political

power is a limited resource; defense officials can engage in debates like that involved in the XM-1 case on only a limited basis if they wish to see *any* collaboration take root. Thus, they should choose collaborative projects with care, and with an eye to a political strategy that in each case has the best chance of insuring successful implementation.

IV. CONCLUSIONS

Three kinds of collaboration in the tank realm, attempted over a period of nearly twenty years, cannot be said to have yielded stunning success. Joint development failed, as rising costs and weight drove first the FRG and then the United States to seek refuge in national tank development projects. West Germany's efforts to sell its Leopard II to the U.S. Army ran afoul of U.S. military requirements, and in any case were impeded by the existence of a U.S. tank, the XM-1, about to enter full-scale development. Only the component exchange has produced results--the very significant agreement to place Germany's 120mm gun on XM-1 tanks after 1984--but even here the potential of the 1976 Addendum has yet to be exploited fully. If all goes well with the U.S. Army's "120mm gun development program" XM-1 tanks will carry German guns--but only some twenty years after the two nations first agreed to collaborate in the development of their main battle tanks.

It is difficult to deal very precisely with the costs--in terms of time as well as money--of collaboration, largely because it is impossible to know what might have been the case had collaboration not occurred. It could be argued, for example, that its unsuccessful attempt to collaborate on the MBT-70 delayed the Army's development of a replacement for the M-60 by some fifteen years, from 1965, when it had been planning to field the tank it began to develop in 1957, to 1980, when the XM-1 finally went into production. Given the ambitious set of requirements the service had approved in 1959 for its new tank, however, it is not clear that the Army could have developed that tank completely by 1965, nor that initial cost estimates would have proved even slightly accurate. Indeed, given the ambitious set of requirements set out in 1959, which included many of the ideas that ultimately added to the MBT-70's complexity (three-man crew, hydropneumatic suspension, automatic loader and the like), that development project might well have suffered the same fate as the XM-803. Or perhaps not.

Likewise, although the XM-1 program's cost and schedule have not changed significantly in response to more recent collaborative efforts, it could be argued that the $181 million the Army now is spending on development of the FRG's 120mm gun is money that could have been spent more usefully on other Army programs. Yet this overlooks the possibility that at some point in the 1980s the Army might have been moved by purely military considerations to mount a new gun on the XM-1, a gun it then would have had to develop either on its own or from other designs. In this case, too, comparative costs escape even rough delineation.

It is difficult to pin down the costs of collaboration, it nonetheless can be said that in neither the MBT-70 nor the XM-1 case did collaboration produce or seem likely to produce any real financial savings. There was no "rationalization" of production under way that would have resulted in a net savings to the Alliance as a whole, or at least to the U.S. and the FRG. Rather, added expense arising from the duplication of development and production facilities seemed to be the rule. This was true, for example, in the case of the development of a multitude of MBT-70 components. To be sure, McNamara had hoped that *production* of MBT-70 components could be distributed between West Germany and the United States on the basis of comparative advantage. Nothing in the pattern of that tank's development, however, suggests that this would have happened. Duplication of production is more clearly the case with the XM-1's 120mm gun, which will be produced in both the United States and the FRG. Indeed, in the 120mm gun case it might be said that the United States is *spending* money, not saving it, in order to buy the presumed military benefits of interoperability and the political benefits of a "two-way street" between the U.S. and its NATO allies.

What has made collaboration so difficult? One answer to this question is that there is no answer, or at least no *single* answer. Rather, a wide variety of factors helps account for specific failures. The fact that West German engineers owned the rights to their inventions seems to have caused significant problems during negotiations to formulate the MBT-70 requirement. The fact that the XM-1's

development schedule fell somewhat less than two years behind that of the Leopard II became the basis for the FRG's refusal to consider the American tank as a possible candidate for the Bundeswehr's inventory. And the fact that the Bundeswehr had not yet developed an equivalent of the U.S. Army's "special armor" made it difficult indeed for the Leopard II to meet the U.S. tank requirement. The weapons acquisition process within a single nation is shaped by a complex array of forces eminating from industry, the research community, the military services and national political institutions. We should not be surprised when weapons acquisition that involves collaboration across national boundaries is also a complicated and difficult process.

This said, however, it must also be said that one seemingly fundamental barrier to collaboration, one thread that runs through all three cases, is the immutability of military requirements. In the early stages of the MBT-70 program, the sanctity with which each army viewed its own tank requirements helped drive the joint tank requirement to higher levels of risk and technical sophistication. In 1968, the importance of the Bundeswehr's 50 ton weight requirement became the chief basis for the FRG's departure from that program, just as the importance of the U.S. Army's survivability requirements made the Leopard II unacceptable to it eight years later. At present, the Bundeswehr's specific engine requirements have prevented it from accepting the U.S. turbine engine, thereby limiting the promise of the component exchange. Repeatedly, military requirements have appeared to stand in the way of collaboration.

To be sure, military requirements may be carrying the burden for a host of other reasons why one nation does not wish to collaborate with another. The Bundeswehr's 50 ton weight requirement, for example, did not prevent it from developing the 61 ton Leopard II. Requirements can change, of course, but a reading of the MBT-70 story suggests that there were a great many reasons why the FRG wanted out of its commitment to the development of an increasingly expensive and sophisticated tank. Likewise, the U.S. Army's reference to its stringent survivability requirement in rejecting the Leopard II, while perhaps legitimate in its own right, should not obscure the fact that

in any case it would have been difficult for the U.S. Army to drop the half-completed XM-1 development program, as important as it was to the service as well as to the Congress, and blithely purchase a German tank.

Nonetheless, references to military requirements appear in these cases often enough, and in enough different contexts, to suggest strongly that they in fact have special significance for collaboration. They are significant, first, because they differ between armies, and, second, because these differences seem to be non-negotiable. On the one hand, requirements differ because doctrines differ and ultimately because there is no basis for universal agreement on what constitutes the best approach to fighting wars. On the other hand, differences in military requirements are difficult to reconcile because the doctrines that govern them serve to integrate fighting forces whose components--weapon systems included--must mesh smoothly if the force is to fight effectively. Changing the requirements for a major system like the tank might well produce repercussions that extend to other components of a nation's fighting force.

But there is more to it than this. A look at the requirements formulation process for the XM-1--a process that took several months during which a conspicuous effort was made to establish consensus across a large number of tank "users"--suggests that when a military service formulates the requirements for a major system it is engaged in a deeply inward-looking organizational process. It is dealing with a weapon system that has symbolic as well as technical importance to those who will man, fight, and perhaps die in it. The groundwork behind the development of such a system thus is serious business, as it clearly was in the case of the XM-1. It should not be surprising that, once consensus on a set of requirements is achieved, threats to that consensus--and collaboration can be one of these--are not taken lightly.

If major systems like the tank have a symbolic as well as a technical reality to the services that develop them, it may well be that the most basic of all military requirements is that, to the extent that the choice is available, the new system be developed by

the service itself. To be sure, nothing in these cases explicitly supports this point: it would do nothing for U.S.-FRG relations to make the point explicitly. Yet intuitively it does not seem surprising that the U.S. Army rejected the Leopard II, or that the Bundeswehr never considered the XM-1. Indeed, it is difficult to imagine any major military service possessed of the industrial capacity and financial resources to develop its own major systems nonetheless buying a "foreign" system.

For all these reasons military requirements rise often in these cases as impediments to collaboration. They also may be expected to arise in other collaborative efforts, especially those involving major systems. In conjunction with other, less fundamental impediments, military requirements in fact may be expected to make collaboration a difficult, expensive, and time-consuming process that is likely to demand the kind of high-level attention that has produced the one success of the U.S.-German experience, the 120mm gun deal.

That statement perhaps can be turned around: if collaboration is likely to be difficult, expensive and demanding of high level attention, then less ambitious efforts like the gun purchase may be the best route to successful collaboration. By exchanging components, nations can effectively sidestep the problems posed by differing doctrines and military requirements. Within limits, a gun or a fire control system is much less likely to violate the military requirements of the buying Army than an entire tank. Nor is exchanging a few components as likely to disrupt the domestic, political and industrial relationships that can surround a system as it proceeds through the development process. Limited component exchanges may represent a modest goal amidst the very ambitious collaborative effort embodied in, say, the MBT-70 project. But for that very reason they promise only modest disruption of the various forces that make collaboration so difficult.

Nor is an exchange of components, however modest its goal, necessarily an insignificant mode of collaboration. If the military and political benefits that attend collaboration are deemed to be worth pursuing, then it must be admitted that as modest a success as the

120mm gun purchase can produce significant results. After 1984 the new U.S. and West German main battle tanks will each fire the same ammunition. They also will use the same fuel, though not as a result of collaboration. And they may also employ whatever other common components--treads, for example--may be agreed upon before that time. They will be interoperable in terms of "consumables"--fuel and ammunition--and these are not only expensive items, but also the items which, if common among or between the tanks of allies, are likely to produce the most significant military benefits.

To be sure, the conclusion that component exchange represents a feasible and perhaps significant form of collaboration is not one that can be extended casually from tanks to other kinds of weapon systems. Tanks seem to be relatively loosely integrated systems: new engines, guns and fire control systems can be mounted on an existing tank without unduly upsetting the balance of the overall system.[1] Indeed, the incorporation of newer components into existing tank models has been the traditional means of improving tanks in both the United States and the Soviet Union.[2] It is not clear that the same kind of loose integration characterizes systems like jet aircraft, for example.

In the tank realm, however, component exchanges would seem to constitute a realistic approach to collaboration. This is not to say that exchanging components is easy, but merely that it probably will be easier than the other collaborative efforts described here. Moreover, the lessons of Section III apply: collaborative projects of this nature still will have to be chosen judiciously, on the basis of their technical feasibility and military desirability, and also with due consideration of essentially political strategies regarding their implementation. This having been done, the Department of Defense can pursue collaboration of this sort knowing that, though its goals may be modest they are also feasible, and that they may still produce significant results.

Appendix A

CO-DEVELOPING TANKS: MILESTONES, 1961-71

YEAR	MONTH	EVENT
1961	April	U.S.-FRG discussions begin
196		U.S., FRG agree to develop tank components jointly
1963	August	U.S., FRG agree to develop MBT-70
1964	January	Lockheed Sunnyvale begins parametric study of tank design
	September	First meetings of Joint Engineering Agency (JEA), Joint Design Team, in Koblenz, FRG
1965	February	Lockheed study concluded
	March	U.S., FRG agree on joint requirement
	August	50-50 cost-sharing formula breaks down; U.S. agrees to fund larger share of development
1967	July	First MBT-70 prototypes appear in U.S.
1968	August	"Major investigation" of MBT-70 program in Congress
1969	April	FRG ends joint funding, reduces projected MBT-70 buy, begins to develop another tank (the Leopard II)
1970	January	U.S. formally ends joint program, begins XM-803 program
1971	December	XM-803 program cancelled; initial work on XM-1 begins

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Appendix B

XM-1 PROGRAM AND TANK COLLABORATION MILESTONES, 1971-79

YEAR	MONTH	XM-1 PROGRAM EVENTS	TANK COLLABORATION EVENTS
1971	December	XM-803 Program Cancelled, funds approved for new tank program.	
1972	February	Main Battle Tank Task Force begins 6 months of deliberations on XM-1 requirement.	
1973	June	XM-1 advanced development contracts let to GM, Chrysler.	James Schlesinger, George Leber begin discussions of collaboration across XM-1, Leopard II programs.
1974	March		U.S., UK, FRG agree to test tank guns (Tripartite gun trials).
	December		U.S., FRG sign two-part Memorandum of Understanding (MOU): 1. U.S. agrees to test Leopard II for possible purchase 2. Both nations agree to "make all reasonable efforts" to achieve maximum standardization of XM-1, Leopard II
1975	March		Trilateral Gun Trials held in U.K.
1976	July	Army completes competitive evaluation of GM, Chrysler, XM-1 prototypes, prepares to name winner on July 30.	
			U.S., UK agree to test British tank gun in United States.
			U.S., FRG sign Addendum to December 1974 MOU, agree to exchange components.
		XM-1 source-selection delayed 120 days to allow turret redesign.	
	September		"XM-1 Tank Panel" investigates component exchange.
			"Hillis Resolution" delays 120mm gun decision from January 1977 to December 1977.
			U.S. Army begins testing of Leopard IIAV; FRG withdraws from competition in December.
	November	Chrysler awarded full-scale engineering development for XM-1 (includes dual-turret for 105mm, 120mm guns).	
1977			U.S., FRG, UK tank guns, ammunition tested in U.S.
1978	January		U.S. Army selects FRG 120mm gun for inclusion in later models of XM-1; "Joint Minutes" to this effect concluded with FRG.
	April		House Armed Services Committee considers Army reprogramming request for funds to develop FRG gun.
	September		Congress approves gun development program.
1979	March	DSARC III: Low-rate initial production of XM-1 begins.	Revised "Joint Minutes" approved, work begins on development of 120mm gun. (Hereafter, 120mm gun development becomes part of XM-1 program).

FOOTNOTES, SECTION II

1. The M-48's parentage lay in the T-20 series of prototypes developed by the U.S. Army Ordnance Department beginning in 1943. To make the M-60, the Army converted the M-48's gasoline engine to a diesel and replaced its 90mm main gun with a British 150mm main gun. See Arthur J. Alexander, *Armor Development in the Soviet Union and the United States*, The Rand Corporation, R-1860-NA, September 1976, pp. 83-99, 104-105.

2. LTC Philip L. Bolte, "MBT-70: A Case Study in Research and Development," (unpublished essay, U.S. Army War College, 6 March 1970), pp. 6-7.

3. LTC Stan R. Sheridan, "U.S./FRG Main Battle Tank: A Case for Joint Development?", (unpublished essay, Industrial College of the Armed Forces, 31 March 1970), pp. 13-14.

4. Ibid., pp. 14-15. Sheridan quotes a *US Position Paper* entitled, "US/German Tank Developments," dated 22 November 1961.

5. See Alexander, *Armor Development*, pp. 100-105.

6. House Committee on Appropriations, Subcommittee on the Department of Defense, *DoD Appropriations for 1966, Hearings*, 89th Congress, 1st Session, Part 5, pp. 250-251.

7. Bolte, "MBT-70," p. 43. See also M. Hochmuth, *The Effect of Structure on Strategy: The Government Sponsored Multinational Joint Venture* (unpublished DBA Thesis, Harvard School of Business Administration, 1972), pp. 334-335. For a general discussion of the nation's balance of payments problem and its influence on the nation's dealings with its allies, see Brigadier General E. Vandevanter, Jr., *Coordinated Weapons Production in NATO: A Study of Alliance Processes*, The Rand Corporation, RM-4169-PR, November 1964, pp. 21-34.

8. Major General Welborn G. Dolvin, *Lessons Learned: Joint International Program Management for the U.S./FRG Main Battle Tank* (Rock Island, Illinois: U.S. Army Management Engineering Training Agency, September 1966), p. 59.

9. Ibid.

10. Bolte, "MBT-70," p. 12, and Sheridan, "U.S./FRG Main Battle Tank," p. 19.

11. R. Meller, "Federal Germany's Defense Potential, Part 2: The Defense Industry," *International Defense Review*, March 1974, pp. 335-339.

12. The FRG's decision to enter the MBT-70 project came soon after it had signed the wide-ranging Franco-German Treaty of 1963. West Germans thus may have felt with some urgency a need to reemphasize their close ties to the United States by, among other things, agreeing to an ambitious collaborative tank development program that the U.S. Secretary of Defense appeared most anxious to begin. For more on the 1963 treaty, and on Franco-German defense cooperation in general, see "Franco-German Cooperation in Defense," *Military Technology and Economics*, March 1977, pp. 10-20.

13. Bolte, "MBT-70," p. 12.

14. Dolvin, *Lessons Learned*, p. 38.

15. LTC John G. Jones, "An Analysis of Management Decision-Making in Weapon System Design Concept Selection: United States/Federal Republic of Germany Main Battle Tank" (unpublished essay, Industrial College of the Armed Forces, 1967), p. 49. Jones, a participant in the joint program, here quotes a speech Dolvin made before the National Security Association in September 1966.

16. Ibid. For a brief summary of Lockheed's work in the PD/CE Study, see ibid., pp. 37-49.

17. See Dolvin's statement to this effect, quoted in Scot MacDonald, "Why the U.S.-German Main Battle Tank Is An Excellent Example of Cooperation," *Armed Forces Management*, January 1967, p. 54.

18. U.S. services have their own technical commands--the Army's Development and Readiness Command (DARCOM) being a case in point. In the FRG, the Ministry of Defense takes care of all materiél development and purchasing through its Federal Defense Equipment and Procurement Office, the equivalent of the Office of Director, Defense Research and Engineering (DDR&E) in the U.S.

19. It is worth noting that, in hurrying to keep pace with the Germans, Dolvin had to run this competition well *before* a joint concept had been produced. Competing firms (GM, Chrysler, and Food Machine Corporation) had access to preliminary concept work done by Lockheed Sunnyvale, but for the most part bid on the basis of their own concept work. As General Dolvin notes in his *Lessons Learned* (p. 215), "Each firm was encouraged to submit what it considered to be the best weapon system concept. . ."

20. Dolvin, *Lessons Learned*, p. 44.

21. Hochmuth, *Effect of Structure on Strategy*, pp. 359-360.

22. Ibid., p. 336.

23. Sheridan, "U.S./FRG Main Battle Tank," p. 18. Sheridan notes that in 1963, when the estimated cost of the joint program was $80 to $100 million, the U.S. expected to spend $118 million *of its own funds* on developing Shillelagh (this included funds already invested in the system's development).

24. Ibid., p. 18.

25. See Bolte, "MBT-70," for doctrinal issues. It is important to note that the high hit probabilities accorded missiles like the Shillelagh were computed without consideration of battlefield degradations in the system's effectiveness due to the enemy's use of smoke, operator error, or the like.

26. Ibid., and Scot MacDonald, "Why the U.S.-German Main Battle Tank Is An Excellent Example of Cooperation," *Armed Forces Management*, January 1967, p. 53. Although the U.S. Army had its complement of light tank advocates, these officers were not in a position to influence the Army's tank requirement.

27. For a general discussion of German tank concepts, see Fred Schrier, "Leopard 2--Main Battle Tank for the '80s," *International Defense Review*, No. 3, 1974, pp. 347-348.

28. Walter Andrews, "'Major Investigation' of MBT-70 Program," *Armed Forces Journal*, September 21, 1968, p. 17.

29. Interview with Mr. Joseph B. Hayes, currently at Detroit Diesel Allison, in Detroit on 9 October 1978. Mr. Hayes was Chief Engineer at the U.S. Army Tank Automotive Command throughout the MBT-70 program.

30. Although this was the case for GM and the MBT-70 project, it has not necessarily been standard U.S. practice. Especially in the 1970s, U.S. contractors under certain circumstances have been able to obtain the rights to inventions arising from work for the government.

31. Interview with Mr. C. D. Trestrail of Detroit Diesel Allison, in Detroit on 9 October 1978. Mr. Trestrail was a member of the JDT. See also Hochmuth, *Effect of Structure on Strategy*, pp. 360 63.

32. Dolvin, *Lessons Learned*, p. 95.

33. Bolte, "MBT-70," p. 56. Bolte also notes that the PD/CE study favored a longer range, supersonic missile and less radiological protection, neither of which finding seems to have influenced the joint requirement.

34. Interview with LTG Welborn G. Dolvin, USA (Ret.), in Washington, D.C., 10 October 1978. As will become clear later in this section, the U.S. Army was itself somewhat divided over the gun/missile issue. Satisfying the Germans in this case also satisfied the U.S. Army's own group of gun proponents.

35. Sheridan, "U.S./FRG Main Battle Tank," p. 52.

36. *Jane's Weapons Systems, 1969-70* (London: Jane's Yearbooks), p. 211.

37. The MBT-70's engine was to be two-thirds the size of the M-60's engine, but capable of 100 percent more power. See Andrews, "'Major Investigation'," p. 17.

38. Sheridan makes this point in his "U.S./FRG Main Battle Tank," p. 52.

39. Quoted in Hochmuth, *Effect of Structure on Strategy*, p. 371.

40. Dolvin interview.

41. See again pp. 8-9 and footnote 13.

42. Although U.S. Army tank experts may have seen the joint program as nothing more than a continuation of the joint component development effort, at least some General Motors personnel expected to work directly with their German counterparts. Trestrail interview.

43. Interview with Mr. Lyle A. Wolcott, currently of the Army's XM-1 program office. Formerly of the Tank Automotive Command, Mr. Wolcott was the chief U.S. designer of the MBT-70's turret. He feels that he and his German counterpart worked closely in laying out the turret's design, though components of the turret were developed separately on a national basis.

44. Quoted in Sheridan, "U.S./FRG Main Battle Tank," p. 41.

45. It is important to note that the Shillelagh's continued development was not funded jointly. In this country the Shillelagh system originally had been funded from the M551 "Sheridan" Armored Reconnaissance Vehicle program budget. It continued to be funded from that source after 1963.

46. Sheridan, "U.S./FRG Main Battle Tank," p. 41.

47. Bolte, "MBT-70," pp. 25-26. The U.S. also pursued the development of a turbine engine, though on a small scale until the U.S. primary engine development program began to suffer problems.

48. Major General Edwin H. Burba, "MBT-70," *Ordnance*, March-April 1968, p. 478.

49. Sheridan, "U.S./FRG Main Battle Tank," p. 41.

50. Craig Liske and Barry Rundquist, "The Politics of Weapons Procurement: The Role of Congress," Monograph Series in World Affairs, University of Denver, 1974, p. 49.

51. Bolte, "MBT-70," pp. 26-27. See also U.S. Congress, House, Committee on Appropriations, *DOD Appropriations for 1972*, 92nd Cong., 1st Sess., Part 5, p. 1390, which notes that the U.S. engine, one of air-cooled design, was supposed to reach an output of 1475 horsepower but overheated severely when it approached that power. For the XM-803 program the engine was derated to 1250 horsepower.

52. Niharte, "Armor for the 1970s," p. 21.

53. Bolte, "MBT-70," p. 27. The U.S. finally committed itself to the Daimler-Benz engine, though the Army apparently was unhappy with the fact that this was a water-cooled rather than an air-cooled design. The service returned to the U.S. engine as soon as the joint program was terminated. See U.S. Congress, House, Committee on Appropriations, *DOD Appropriations for 1972*, Part 6 (92nd Congress, 1st Session), p. 519.

54. Ibid., pp. 28-29.

55. Sheridan, "U.S./FRG Main Battle Tank," p. 50.

56. Dolvin, *Lessons Learned*, p. 141.

57. U.S. Congress, Senate, Committee on Armed Services, *FY1974 Authorization for Military Procurement, Hearings*, Part 4 (93d Congress, 1st Session), p. 2008. For the breakdown between development and procurement funding, see *DMS Market Intelligence Report*, XM-1, March 1977, p. 2.

58. U.S. Congress, Senate, Committee on Armed Services, *FY1974 Authorization for Military Procurement, Hearings*, Part 4 (93rd Congress, 1st Session), p. 2008.

59. Assuming that the FRG allocated its $100 million expenditures in roughly the same proportions as the U.S., their development cost came to about $76 million, making total development cost about $307 million. Using the 1965 baseline cost estimate of $138 million on grounds that this was the first reasonably "hard" cost estimate yields a conservative development cost overrun of 222%.

60. Hochmuth, *Effect of Structure on Strategy*, p. 333.

61. Bolte, "MBT-70," p. 32.

62. Dolvin, *Lessons Learned*, p. 200.

63. This applies to all but duplication of the main gun developments. Although sources are ambiguous, it seems fairly clear that the Germans funded their 120mm gun development unilaterally.

64. Dolvin interview.

65. The measurement issue actually arose over the question of what kind of fasteners would be used in constructing the vehicle. See Dolvin, *Lessons Learned*, pp. 83-84. The compromise worked out at the ministerial level differed very little from those worked out at lower levels from the start of the program: U.S. designers would use U.S. fasteners, Germans would use metric fasteners, but interfaces would be done in metric.

66. Dolvin interview.

67. Bolte, "MBT-70," p. 33, and Sheridan, "U.S./FRG Main Battle Tank," p. 44.

68. Andrews, "'Major Investigation,'" p. 16.

69. Hochmuth, *Effect of Structure on Strategy*, p. 369.

70. Sheridan, "U.S./FRG Main Battle Tank," p. 42.

71. See Niharte, "Armor for the 1970s," p. 21, MacDonald, "U.S./German Main Battle Tank," p. 53, and Sheridan, "U.S./FRG Main Battle Tank," p. 50.

72. Quoted in Sheridan, "U.S./FRG Main Battle Tank," p. 49.

73. Col. Meritte W. Ireland, "MBT70/XM803," *Armor*, July-August 1970, p. 33. See also Bolte, "MBT-70," p. 41.

74. Sheridan, "U.S./FRG Main Battle Tank," p. 68.

75. Bolte, "MBT-70," p. 41.

76. Taken from ibid., p. v., this quote comes from Packard's testimony before the Senate Armed Services Committee. Packard also expressed concern for the excessive duplication that had marked the program--ibid., p. 50.

77. Liske and Rundquist, "Politics of Weapons Procurement," p. 56.

78. Liske and Rundquist, "Politics of Weapons Procurement," pp. 63-64.

79. See "Austere MBT-70 Still Superior," *Armed Forces Journal*, 11 July 1970, p. 14.

80. For problems in the MBT-70 redesign, see Gerald T. Croskery and Cyril F. Horton, "XM-1 Main Battle Tank," *Defense Management Journal*, September 1974, p. 40. The cost quotes are from U.S. Congress, House, Committee on Appropriations, *DoD Appropriations Bill 1972* (92nd Congress, 1st Session), p. 74.

81. Dolvin and Hayes interviews.

82. Liske and Rundquist, "Politics of Weapons Procurement," p. 69.

83. Ibid., p. 69.

FOOTNOTES, SECTION III

1. The committee leveled this charge at the MBT-70 in 1969, along with a recommendation that the joint development program be terminated. Two years later it leveled the same charge at the XM-803 and recommended that the entire project be terminated. See House Committee on Appropriations, *Department of Defense Appropriations, 1972*, 92nd Cong., 1st Sess., pp. 73-74.

2. House Committee on Appropriations, *Department of Defense Appropriations, 1972*, 92nd Cong., 1st Sess., p. 73.

3. House Committee on Appropriations, Subcommittee on Department of Defense, *FY1973 DoD Appropriations, Hearings*, 92nd Cong., 2d Sess., Part I, p. 452.

4. House Committee on Appropriations, *Department of Defense Appropriations, 1972*, 92nd Cong., 1st Sess., p. 74.

5. Ibid.

6. See Liske and Rundquist, "Politics of Weapons Procurement," pp. 71-72, for the specific political activities in the Congress that made a position held by the House Appropriations Committee and some members of the House Committee on Armed Services (notably Samuel Stratton) the position of the Congress as a whole.

7. This account of the XM-1 requirements process relies heavily on work done at The Rand Corporation between 1973 and 1975 by Dr. Arthur Alexander. Published results of this work appears in his *Armor Development in the Soviet Union and the United States*, The Rand Corporation, R-1860-NA, September 1976, pp. 110-114; and in the *Report of the Commission on the Organization of the Government for the Conduct of Foreign Policy* [the Murphy Commission Report], Volume 4, Appendix K (Washington, D.C.: Government Printing Office, June 1975), pp. 199-207 (referred to hereafter as Alexander, *Murphy Commission Report*). This essay relies on these sources, unpublished notes taken by Dr. Alexander during interviews held in 1974 with Army personnel involved in the XM-1 development, and my own interviews with Program Office personnel, conducted in October 1978.

8. The Task Force was compelled to face this broad issue by several Congressmen who, in criticizing the XM-803, suggested that new antitank missiles might make unnecessary the design of a new tank. These Congressmen recommended that the Army upgrade the M60A1 while investing in the development of "a weapons system designed to counter the growing antitank capability which threatens to outmode the MBT-70/XM-803 even before it is in inventory." See Liske and Rundquist, "Politics of Weapons Procurement," pp. 58-59.

9. For the tank's cost figure, see House Committee on Armed Services, Subcommittee on Research and Development, *FY1975 Hearings on Military Posture*, 93rd Cong., 2d Sess., Part 4, p. 3900. Information on the tradeoff process is taken from interview notes, Arthur Alexander with Brigadier General Charles Heiden (Deputy Director of the Main Battle Tank Task Force) in Washington, D.C., in October 1974.

10. Testimony of Brigadier General Robert J. Baer, the first XM-1 program manager: Senate Committee on Armed Services, Subcommittee on Research and Development, *FY1974 Authorizations for Military Procurement, Hearings*, 93d Cong., 1st Sess., Part 4, p. 1975.

11. Alexander-Heiden interview.

12. For a useful overview of the XM-1 program, see General Baer's testimony to the Senate Committee on Armed Services, Subcommittee on Research and Development; *FY1976 and 7T Authorizations, Hearings*, 94th Cong., 1st Sess., Part 6, pp. 3167ff.

13. Senate Committee on Armed Services, Subcommittee on Research and Development, *FY1974 Authorizations for Military Procurement, Hearings*, 93d Cong., 1st Sess., Part 4, p. 1979.

14. See Alexander, *Murphy Commission Report*, p. 202.

15. Ibid., p. 205.

16. Interviews with XM-1 program office personnel, in Warren, MI, on October 13, 1978.

17. House Committee on Appropriations, Subcommittee on DoD, *FY1970 DoD Appropriations*, 91st Cong., 1st Sess., p. 73.

18. These interviews were conducted by Liske and Rundquist and are cited in their "Politics of Weapons Procurement," p. 61.

19. Ibid., p. 64.

20. Senate Committee on Armed Services, Subcommittee on Research and Development, *FY1971 for Military Procurement, Hearings*, 91st Cong., 2d Sess., Part 2, p. 884.

21. See General Baer's testimony, Senate Committee on Armed Services, *FY1976 and July-September 1976 Transition Period Authorization for Military Procurement, Hearings*, 94th Cong., 1st Sess., Part 6, pp. 3179, 3183-84.

22. This is the testimony of Brigadier General Philip L. Bolte, Deputy Commanding General of the U.S. Army's Testing and Evaluation Command, before the Investigations Subcommittee of the House Committee on Armed Services in April 1978; *Army Reprogramming Request No. 78-14 P/A, FRG Smooth Bore 120-MM Gun and XM-1 Tank,* 95th Cong., 2d Sess., p. 30. (Referred to hereafter as *Reprogramming Hearings.*)

23. See Alexander, *Armor Development in the Soviet Union and the United States,* p. 113; General Baer's testimony, Senate Committee on Armed Services, *FY1976 and July-September 1976 Transition Period Authorization for Military Procurement, Hearings,* 94th Cong., 1st Sess., Part 6, p. 3181; and Benjamin F. Schemmer, "NATO's New MBT 'Gun' Will be 3 New Guns," *Armed Forces Journal International,* April 1976, p. 12. Schemmer contends that the new round "offered a growth potential which exceeded tripartite [i.e., US, FRG, and UK] goals by 50 percent in range."

24. See General Baer's testimony, Senate Committee on Armed Services, *FY1976 and July-September 1976 Transition Period Authorization for Military Procurement, Hearings,* 94th Cong., 1st Sess., Part 6, p. 3181.

25. *Reprogramming Hearings*, p. 30.

26. The term "harmonization" was used in the 1976 Addendum and refers to the process by which major *subcomponents* of two nationally developed systems are standardized.

27. General Accounting Office, Report to the Congress, "Department of Defense Consideration of West Germany's Leopard as the Army's New Main Battle Tank," November 28, 1977, p. 3.

28. Letter quoted in ibid., p. 3.

29. See the comments of Edward A. Miller, Assistant Secretary of the Army for Research and Development, in House Committee on Armed Services, Investigations Subcommittee, *Oversight Hearings on the Status of the Army XM-1 Tank Program,* 95th Cong., 1st Sess., pp. 3-5. Referred to hereafter as *Oversight Hearings.*

30. James R. Schlesinger, *Annual Defense Department Report, FY1976 and TT,* March 1975, p. III-51.

31. See the letter from Secretary of Defense Donald Rumsfeld to Representative Samuel Stratton, reproduced in Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform,* 94th Cong., 2d Sess., Part 3, p. 24.

32. This is the statement of Deputy Defense Secretary William Clements. See Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform*, 94th Cong., 2d Sess., Part 3, p. 13.

33. "U.S. Army Explains XM-1 Gun Choice," *International Defense Review*, #3/1978, p. 441.

34. Agreement quoted in GAO, "DoD Consideration of West Germany's Leopard," p. 3.

35. U.S. Congress, Senate, Committee on Armed Services, Subcommittee on Research and Development and Subcommittee on Manpower and Personnel, *European Defense Cooperation, Hearings*, 94th Cong., 2d Sess., p. 35.

36. Another reason the Germans were loath to consider the XM-1 was that many apparently tied U.S. purchase of the German tank (or, barring that, the German tank gun) with German participation in the U.S. AWACS program. See ibid., p. 5.

37. See "The Leopard 2AV: German Hope for a Standard NATO Tank," *International Defense Review*, #1, 1976, pp. 111-114.

38. For a useful description of the Leopard IIAV, see G. M. Bailly-Cowell, "MBT Leopard 2AV for NATO?", *NATO's Fifteen Nations*, June-July 1976, pp. 19-30.

39. GAO, "DoD Consideration of West Germany's Leopard," p. 4.

40. Quoted in *Oversight Hearings*, p. 6.

41. Ibid., p. 7. Cost of the study was set at $2 million, with Food Machine Corporation (FMC) as the U.S. participant.

42. This is Secretary of Defense Rumsfeld's statement, as quoted in R.M.D. Furlong, "The XM-1 Tank Program--A Status Report," *International Defense Review*, #3/1976, p. 481. Note the comment of the Army's Assistant Secretary for Research and Development, made in March 1977: "[T]he commitment to adopt the Leopard design was verbal only by the Secretary of the Army and is not included in this memorandum of understanding." See *Oversight Hearings*, p. 7.

43. See James R. Schlesinger, *Annual Defense Department Report, FY1976 and FY197T*, March 1975, p. III-52, where Schlesinger noted that the Army's FY1976 funding request for the XM-1 included funds for the "initiation of engineering development."

44. House Committee on Armed Services, *Authorizing Appropriations, Fiscal Year 1976 and the Period Beginning July 1, 1976 and Ending September 30, 1976*, 94th Cong., 1st Sess., especially p. 65.

45. Senate Committee on Armed Services, *Authorizing Appropriations for Fiscal Year 1976 and July-September 1976 Transition Period*, 94th Cong., 1st Sess., p. 88, where the committee also noted that it was "a strong advocate of standardization of weaponry in NATO."

46. House Committee on Appropriations, *Department of Defense Appropriation Bill, 1976*, 94th Cong., 1st Sess., p. 275-76.

47. Senate Committee on Appropriations, *Department of Defense Appropriation Bill, 1976*, 94th Cong., 1st Sess., p. 250.

48. See the GAO, "DoD Consideration of West Germany's Leopard," p. 4, which notes that "The Army was . . . supported in two different Congressional conference committees when proposals by some Members to defer full-scale development until after side-by-side testing with the Leopard were defeated." This report also notes on p. 5 that in November of 1975 the German Director of Armaments, Hans L. Eberhard,

> wrote to DoD expressing concern that the Army was requesting authority to select an XM-1 prototype and enter it into full-scale development 3 months before the Leopard would even begin testing. A year earlier Germany was informed that the tanks could not be tested simultaneously. Apparently, it did not realize that the Army intended to commit funds to the development of the winning U.S. tank.

49. See the testimony of General Baer and the Assistant Secretary of the Army for Research and Development, *Oversight Hearings*, p. 5.

50. Ibid.

51. Quoted in Schemmer, "NATO's New MBT 'gun' Will be 3 New Guns," p. 12. Schemmer notes that use of the 105mm system "would have resulted in 97 percent standardization of the FRG, US, and UK tank fleets by 1995."

52. There have been two technical complaints lodged against the 120mm *caseless* round: First, there are technical problems associated with clearing the bore of residue after the round is fired. These have been of special interest in the U.S. armor community, which was never able to solve these problems with its own 152mm caseless round for the MBT-70. The second problem stems from fears that the caseless round may be more

vulnerable to exploding should the tank's turret be penetrated by anti-tank fire. For an extended discussion of these and other questions concerning the German gun, see General Bolte's testimony, *Reprogramming Hearings*, pp. 35-41.

53. The flexibility stems from the fact that rifled guns can fire more kinds of ammunition than smoothbore guns. Smoothbore guns were developed to exploit innovations in kinetic energy anti-tank ammunition. The penetrating power of such a round varies in proportion to the ratio of its length to its diameter. The longer and thinner, the better. But long, thin projectiles are highly unstable when spun, and must therefore be fin stabilized. This requirement made necessary the use of smoothbore guns, but at a price; smoothbore guns could not fire many of the other kinds of ammunition--antipersonnel, for example--that officers in the U.S. and U.K. thought were useful in combat.

    Further development work, most of it done in the United States, eliminated the need for such tradeoffs by making it possible to fire fin-stabilized projectiles from rifle bores. The projectile is encased in slipping rings that spin in the bore's rifling but impart only a mild spin to the projectile itself. This has been the basis for the U.S. Army's newest 105mm rounds, and it was on this kind of technology that the U.K. decided to develop a rifled 120mm tank gun system.

    For a discussion of these issues, see R.D.M. Furlong and R.B. Penegelley, "Main Armament for the XM-1 Tank--Storm Over the Selection Process," *International Defense Review*, #6, 1976, pp. 989-991.

54. See General Baer's testimony, Senate Committee on Armed Services, Subcommittee on Research and Development, *FY1976 and 197T Authorization for Military Procurement, Hearings*, 94th Cong., 1st Sess., Part 6, p. 3182.

55. See the testimony of Deputy Secretary Clements, ibid., p. 17.

56. Ibid., p. 20.

57. Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform*, 94th Cong., 2d Sess., Part 3, pp. 23-24.

58. *Report of the XM-1 Tank Panel*, p. 3.

59. Interview with Lieutenant General Howard H. Cooksey (U.S. Army Ret.), in Alexandria, VA, on October 12, 1978. General Cooksey was the Army's Deputy Chief of Staff of Research, Development, and Acquisition at the time. He suggested that the presence of his deputy, Major General Philip R. Feir,

in the U.K. in June 1976 was a response to the U.S. Army's interest in the British 120mm gun; OSD's interest was directed at the FRG. Both teams of negotiators knew of the other's activities; that the agreements each negotiated seemed to be in conflict stemmed, in Cooksey's opinion, from the difficulties each team had in reaching an agreement with the nation in question.

60. See Furlong and Penegelley, "Main Armament for the XM-1 Tank," p. 990.

61. A copy of the addendum may be found in Appendix I to the Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform, Hearings*, 94th Cong., 2d Sess., Part 3, pp. 29-38. This quote comes from p. 29.

62. Ibid., p. 30.

63. Ibid., p. 31.

64. Ibid.

65. Ibid., p. 32.

66. Ibid.

67. Ibid.

68. Ibid., p. 36.

69. Ibid., p. 24.

70. Ibid.

71. *Report of the XM-1 Tank Panel*, supra. Army journals were also very critical of the addendum and the schedule slippage that went with it. See "The Tanks Don't Roll--Again," *Army*, September 1976, pp. 11-12; and "A Leopard in Our Tank?", *National Defense*, September-October 1975, p. 152.

72. *Report of the XM-1 Tank Panel*, p. 15.

73. Ibid., pp. 14-15.

74. Ibid., p. 15.

75. Quoted in ibid., p. 15.

76. Ibid., p. 14.

77. Ibid., p. 15.

78. Ibid.

79. See Furlong and Penegelley, "Main Armament for the XM-1 Tank," p. 990.

80. *Report of the XM-1 Tank Panel*, p. 16.

81. Ibid.

82. Ibid., p. 14.

83. Ibid., p. 17.

84. Ibid., p. 9.

85. *Report of the XM-1 Tank Panel*, p. 18.

86. Ibid.

87. See, for example, Senate Committee on Government Operations, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, *Major Systems Acquisition Reform, Hearings*, 94th Cong., 2d Sess., Part 3, supra.

88. See Public Law 95-79, July 30, 1977, *Department of Defense Appropriation Authorization Act, 1978*, Section 204.

89. *Oversight Hearings*, p. 14.

90. F. Clifton Berry, "Were U.S./German Tank Tests Invalid?: Leopard 2 Short-Weighted, Army Found," *Armed Forces Journal International*, May 1977, p. 13.

91. *Oversight Hearings*, p. 35. For a general description of the tests and the results, see ibid., pp. 25-35.

92. See "U.S. Army Explains XM-1 Gun Choice," *International Defense Review*, 3/78, p. 441. For original cost figures on gun development program see Senate Committee on Armed Services, *Department of Defense Authorization for Appropriations, FY1979 Hearings*, 95th Cong., 2d Sess., Part 10, 6975.

93. "U.S. Army Explains XM-1 Gun Choice," *International Defense Review*, 3/78, p. 441.

94. See Dr. William Perry's testimony before the Subcommittee on R&D, House Committee on Armed Services, as quoted by Mr. Stratton in *Reprogramming Hearings*, p. 144.

95. Ibid., p. 42.

96. Ibid., p. 41-42.

97. Ibid., p. 74: As Pierre put it on p. 73, ". . . what is constant is that power is useful."

98. This conclusion is taken from an interview between Dr. Arthur J. Alexander and Dr. Pierre in Washington, D.C., on January 8, 1979.

99. See the Report of the Investigations Subcommittee, *Reprogramming Hearings*, pp. 131-136. This statement is taken from p. 134.

100. *Reprogramming Hearings*, p. 134.

101. See the extended discussion of this point between Representative Stratton and Brigadier General Donald M. Babers, General Baer's successor as XM-1 Program Manager, in *Reprogramming Hearings*, pp. 106ff. See also Stratton's report, ibid., p. 135.

102. See in particular the testimony of Mr. Robert Moore, Deputy Tactical Warfare Programs, DoD, who said in response to Stratton's query on the matter, "I can't tell you where those dollars are going to come from. That will be determined in the budget process. . . I just can't answer that question now as to where the funds would come from." *Reprogramming Hearings*, p. 122.

103. Ibid., p. 136.

104. *Report of the XM-1 Tank Panel*, p. 9.

105. *Reprogramming Hearings*, p. 76.

106. *Reprogramming Hearings*, p. 135.

107. Ibid.

108. Ibid.

109. See House Committee on Armed Services, *Department of Defense Appropriations Authorization Act, 1979, Conference Report*, 95th Cong., 2d Sess., p. 47.

110. House Committee on Appropriations, *Department of Defense Appropriations Bill, 1979*, 95th Cong., 2d Sess., p. 327. The total cost of the gun development program had risen from the $159.1 million originally announced early in 1978 to $171.5 million, as a result of inflation incurred while waiting for Congressional approval of funding for the program.

111. For a description of the revised gun development program, see House Committee on Armed Services, *Supplemental Procurement Authorization for FY1979, Hearings*, 96th Cong., 1st Sess., Part 2, pp. 729ff. At the time of these hearings the U.S. Army envisioned redesigning the breech of the German gun to lower its production costs, the feeling being that the German breech was much more complex than it needed to be. Later, the Germans announced that they had redesigned the breech themselves, and the U.S. accepted the new German breech in October 1979. The U.S. Army's ammunition work will apply the advanced technology developed for the U.S. 105mm round (including the use of depleted-uranium penetrators) to the German 120mm ammunition.

112. Ibid., p. 731.

113. Interview with Dr. Percy Pierre, in Washington, D.C., on 20 September 1979.

114. Compare the licensing arrangements contained in the original joint minutes, found in *Reprogramming Hearings*, pp. 153-155, with the brief synopsis of the new arrangements given in the House Committee on Armed Services, *Supplemental Procurement Authorization for FY1979, Hearings*, 96th Cong., 1st Sess., Part 2, p. 733 (the final licensing agreement is unclassified but not readily available to the public). The main differences lie in the total amount of licensing fee (a maximum of $25 million in the joint minutes, a flat $30 million in the final agreement) and the amount paid "up front" ($5 million in the joint minutes versus $15 million in the final agreement).

115. Significantly, initially the service simply slipped the gun development program by a year, moving the end date out to August 1985, and it briefed this program to the House Armed Services Committee in April 1979 with the proviso that it would "strive . . . to expedite the transition process from 105mm to 120mm caliber . . ." See House Committee on Armed Services, *Supplemental Procurement Authorization for FY1979, Hearings*, 96th Cong., 1st Sess., Part 2, p. 730. OSD apparently asked the service to expedite the program formally in the interest of mounting as many 120 guns as possible on XM-1 tanks. The Army moved the end date for the gun development program up to August 1984 in response to OSD's wishes.

116. See ibid., p. 728, for the most recent discussion of other elements of the component exchange. It should be noted that both tanks will use the same fuel, whether or not the FRG ultimately adopts the U.S. Army's turbine engine.

117. Telephone interview with Col. Samuel Myers, USA, on 28 January 1980. Col. Myers currently oversees Army tank programs from the Office of the Assistant Secretary of the Army (Research, Development, and Acquisition).

FOOTNOTES, SECTION IV

1. I advance the notion of "degree of integration" with some caution. Clearly there are limits beyond which no system will admit to tampering. Within broad limits, for example, the size of a tank's main gun also will determine its minimum weight. It thus might be impossible to place the FRG's 120mm gun on the relatively light weight French AMX-30. Across British, West German and U.S. main battle tanks, however, this limit is not restrictive. Nor was it restrictive in the case of the MBT-70 where the FRG, for example, proposed an alternative gun and engine to those being developed in the United States. Generally, tanks have admitted to component exchange in the past; component exchange thus is likely to remain a viable form of collaboration in the future.

2. See Arthur J. Alexander, *Armor Development in the Soviet Union and the United States* (The Rand Corporation, R-1860-NA, September 1976), supra. Significantly, the M-60's 105mm gun originally was purchased from the British in an exchange not unlike the present U.S.-FRG gun exchange.